AN ANALYSIS OF PARAMETERS AFFECTING VOLUMETRIC AIRFLOW AND EFFICIENCY OF AN IONIC AIR MOVING DEVICE

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ABSTRACT

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Ionic airflow is a phenomenon that is observed when a high electric potential is supplied to at least two electrodes classified as an emitter and a collector. The emitter has a sharp geometric profile such as a needle or thin wire. The collector has a smooth, blunt geometric profile such as a flat plate or ring with sufficient thickness and rounded edges. Air molecules are ionized once high electric potential is supplied. As ionized molecules collide with uncharged molecules in close proximity to the sharp electrode, steady air flow is generated due to transfer of momentum. Ionic air moving devices have the potential to replace fans and blowers, however, they are rarely utilized due to their low efficiency. These devices are of great interest to industry for electronic cooling applications due to their lack of moving parts and potentially silent operation. Previous research has demonstrated that device efficiency and airflow volume can be increased by varying parameters such as: the number of ionization sites, the distance between the ionization sites and the collector, the height of the collector, and the amount of supplied electric potential. In this study, an analysis of parameters including collector material, collector shape, and number of collectors has been conducted. The ionic air moving device parameters were evaluated through the use of a DOE (Design of Experiments) to determine their statistical significance related to volumetric airflow output. Additional investigation was performed to determine the effect of the device parameters on the overall efficiency. Results indicate that collector material, and collector shape have a statistically significant effect on volumetric airflow output. It was also observed that collector material, collector shape, and number of collectors have some effect on overall device efficiency. Further research focused on ionic air moving device parameters will need to be conducted in order to justify device implementation as a practical standalone electronics-cooling device. By optimizing device parameters, ionic air moving device efficiency could be increased to a level that would support their utilization for practical applications.

CHAPTER 1: INTRODUCTION

Ionic air moving devices generate ion-driven airflow by ionizing the molecules of a working fluid located between two electrodes. Each electrode is supplied with a high electric potential ranging from approximately 6,000 to 25,000 volts [25]. The two electrodes are typically classified as emitters and collectors. The emitter has a sharp geometric profile such as a needle or wire. The collector has a smooth, blunt geometric profile such as a flat plate or cylinder. In a negatively charged corona configuration, the emitter is negatively charged while the collector is positively charged. As molecules of the working fluid are ionized at the points of the emitter, they collide with uncharged molecules while attracting towards the collector [25]. This collision of molecules causes a transfer of momentum resulting in generation of steady airflow.

Ionic air moving devices have the potential to replace fans and blowers; however, are rarely utilized due to their low efficiency. These devices are used today mainly as filtration devices. Ionic air moving devices are of interest in the field of electronic cooling applications due to their lack of moving parts and silent operation [25]. However, their implementation is not practical because of their low efficiency in comparison to conventional fans and blowers [27].

The improvement of ionic air moving device efficiency has been the focus of multiple researchers over the years. Previous research has demonstrated that device efficiency and airflow volume can be increased by varying parameters such as: the number of ionization sites, the distance between the ionization sites and the collector, geometry of the collector, and the amount of supplied electric potential [15, 21, 24, 25, 26, 27, 28, 33].

The purpose of this study is to determine whether independent variables of collector material, collector shape, and number of collectors have a statistically significant effect on observed response variable values of airflow and device efficiency. This thesis seeks to answer the following questions:

1. Do collector materials of aluminum, conductive graphite, and copper have a statistically significant effect on ionic air moving device volumetric airflow output or overall efficiency? If so, which material produces the highest of each response variable?
2. Do collector shapes of cylindrical, conical, and parabolic have a statistically significant effect on ionic air moving device volumetric air flow output or overall efficiency? If so, which shapes produces the highest of each response variable?
3. Do the number of collectors at stages of 4-stage, 6-stage, and 8-stage have a statistically significant effect on ionic air moving device volumetric airflow output or overall efficiency? If so, which level produces the highest of each response variable?

1.1 Scope of Thesis

The current study investigates the parameters of ionic air moving devices and their influence on the volumetric airflow output and overall efficiency of the devices. This research is important because the benefits ionic air moving devices offer are highly desired by industry. However, their implementation will not be practical until their performance reaches an acceptable level. This research investigates ionic air moving device parameters of collector material, collector shape, and number of collectors and determines if they have a statistically significant impact on device performance. A DOE (design of experiments) is utilized to establish whether statistical significance is observed for each device parameter.

Multiple iterations of experimental investigation were performed. This included testing device parameters of collector material, collector shape, and number of collectors. The parameter of collector material investigated include: aluminum, conductive graphite, and copper. The parameter of collector shape investigated included: cylindrical, conical, and parabolic. The number of collectors were varied over the levels which included: 4-stage, 6-stage, and 8-stage. The volumetric airflow, static pressure, and current responses of the tested devices were used to determine physical output and overall efficiency of these devices. Further testing was performed by changing the process parameters. Only two process parameters were investigated – supplied voltage level and distance between electrodes.

1.2 Overview of Thesis

The current study briefly introduces some of the current designs and configurations of ionic air moving devices. An overview of current attempts to increase these devices efficiency is investigated. The test equipment that was used for this study will also be discussed. A review of current literature and the phenomena of ionic airflow is provided in Chapter 2.

Chapter 3 presents the experimental design methodology chosen for conducting the research. Test equipment used for the research is described and illustrated. Expected results from testing are discussed. Chapter 4 presents the DOE (design of experiments) utilized for analyzing the results of the research. Additionally, the results are analyzed and discussed in Chapter 4. Chapter 5 summarizes the main findings of this study and provides a scope of future research that can be carried out in the future.

1.3 Key Terms

- Ion-Driven Air Flow: a breakdown of a working fluid into ions in the presence of a high electric field and an electrode with a high curvature.
- Emitter: a sharp high curvature electrode. Typically, a thin wire or needle.
- Collector: the blunt electrode. Typically, a smooth flat plate or thin ring.
- Electric Field: a high voltage field that occurs due to the electrode geometry.
- Electric Arc: A luminous discharge of current that is formed when a strong current jumps a gap in a circuit or between two electrodes.
- Ion: an atom or molecule with a net electric charge due to the loss or gain of one or more electrons.
- Ionization: a process by which air molecules are given a positive or negative charge.
- Electron: a stable subatomic particle with a charge of negative electricity, found in all atoms and acting as the primary carrier of electricity in solids.
- Molecule: a group of atoms bonded together, representing the smallest fundamental unit of a chemical compound that can take part in a chemical reaction.
- Momentum Transfer: lower energy ions hitting neutral molecules causing airflow.
- Corona Discharge: an electrical discharge brought on by the ionization of a fluid such as air surrounding a conductor that is electrically charged.
- Flow Bench: a device that determines the airflow generated by an input as the backpressure is varied from zero to its maximum.
- High Voltage Power Supply: a power source that supplies a high voltage potential between its output terminals.

- Manometer: an instrument (as a pressure gauge) for measuring the pressure of gases and vapors.
- PTC Creo Parametric 3.0®: a family or suite of design software supporting product design for discrete manufacturers. Provides apps for 3D CAD parametric feature solid modeling, 3D direct modeling, 2D orthographic views, Finite Element Analysis and simulation, schematic design, technical illustrations, and viewing and visualization.
- 3D-Printing: the action or process of making a physical object from a three-dimensional digital model, typically by laying down many thin layers of a material in succession.
- PLA Filament: a biodegradable and bioactive thermoplastic aliphatic polyester derived from renewable resources, such as corn starch, tapioca roots, chips or starch, or sugarcane.
- Conductive Graphite: a material that can conduct electricity due to the vast electron delocalization within the carbon layers (a phenomenon called aromaticity).
- DOE: Design of Experiments.
- Design of Experiments: a structured experimental strategy where factors have discrete levels that allow for simultaneous evaluation of processing variables related to their ability to influence a product or process characteristic.
- Factors: process variables being investigated (X value).
- Level: values or settings at which the factors are evaluated.
- Response: process characteristic that is measurable (Y value).
- LabVIEW®: Laboratory Virtual Instrument Engineering Workbench.
- Laboratory Virtual Instrument Engineering Workbench: a graphical programming environment that creates programs in order to read measurements and data, analyze data, and present results.

- G-Programming: the graphical programming language used in LabVIEW®.
- Sub VI: a sub-program of LabVIEW®.
- Main VI: the primary program of LabVIEW®.
- Front panel: the user input window for monitoring and control.
- Block Diagram: the wiring configuration to perform the graphical method of programming.
- Minitab®: A statistical analysis software.
- ANOVA: Analysis of Variance.
- Analysis of Variance: Statistical methods used to test the difference of means for three of more groups
- Matlab®: a multi-paradigm numerical computing environment and fourth-generation programming language.
- Paradigm: a set of linguistic items that form mutually exclusive choices in particular syntactic roles.
- Polynomial Curve: an algebraic expression consisting of one or more summed terms, each term consisting of a constant multiplier and one or more variables raised to non-negative integral powers.

CHAPTER 2: LITERATURE REVIEW

This chapter provides the background for this study along with a review of the literature that has been used for reference during different stages of the research. The properties of ionic air moving devices are discussed in addition to some of the recent findings reported in the literature.

2.1 Overview

Ionic airflow is a phenomenon that occurs when a high electric potential is supplied between two electrodes of specific geometries. For the current research, electric potential supplied to the electrodes can reach up to 25,000 volts. Generally, higher electric potential results in greater generated airflow [25, 33]. For the current study, supplied voltage level ranged from 6,000 to 25,000 volts. Typically, the electrodes are categorized as emitters and collectors. The emitter usually has a sharp geometric profile like that of a needle or wire. The collector is commonly a blunt object such as a flat plate or cylinder. When a high electric charge is applied to the electrodes, the working fluid is broken down into ions [25]. Generated ions collide with neutral molecules gaining momentum as they move towards the opposite electrode [25]. Ions flow from the emitter electrode towards the collector electrode. The result of momentum transfer between ions and molecules is a steady flow of air known as ionic airflow. Ionic air moving devices offer many beneficial features for industrial electronic cooling purposes. There are no moving parts, which means they are more reliable and require less maintenance than conventional fans [27]. Virtually silent operation and lack of vibration is another desired feature these devices offer. Literature has suggested ionic air moving device efficiency can be increased by optimizing geometric parameters; however, current volumetric air output and overall efficiency is not at a level that would justify practical implementation as an air moving device [15, 21, 24, 25, 26, 27, 28, 33]. This study aims to investigate geometric parameters of an ionic air moving device and determine if a statistically significant effect on volumetric airflow output and overall efficiency is observed by varying device parameters such as: collector material, collector shape, and number of collectors (stages).

2.2 Testing Method

This section provides a brief description of the methods used for testing the volumetric airflow output and overall efficiency of the ionic air moving device.

2.2.1 Needle to Ring Electrode Configuration

Ionic air moving devices consist of two essential components classified as the emitter and the collector [25]. The emitter requires a sharp geometric profile. Ionization of air molecules occurs at the sharp profile of the emitter. Typically, a thin wire or needles are used for the emitter electrode. The collector should be a smooth, blunt object. Preferably, the collector will not contain any sharp points or edges as ionization of air molecules is not desired at the collector because this would cause an opposing flow of ions and the working fluid [25]. A smooth flat plate or thin ring are normally used as collectors. For this research, an array of needles was chosen for the emitter and ring type collectors were used. The emitter consisted of five equally spaced needles. Collectors used in the research varied in shape including cylindrical, conical, and parabolic. Figure 2.1 shows the emitter and one of the ring type collectors used in the research.

Figure 2.1: Needle type emitter and ring type collector.

2.2.2 Negative Corona Configuration

When the emitter electrode is connected to the negative lead of the power supply, a negative corona is produced when a high enough electric potential is available. In a positive corona configuration, the emitter electrode is connected to the positive lead of the power supply. During operation of a negative corona configuration there are three regions of importance classified as: the ionizing plasma region, the non-ionizing plasma region, and the unipolar region [25]. In the ionizing region, air molecules are ionized around the needlepoints of the emitter and creation of electrons occurs [25]. Positive ions are also created due to natural ionizations events. With a high electric field supplied, electrons begin flowing towards the positively charged collector and positive ions group around the negatively charged emitter needlepoints. As the negative ions begin to flow towards the collector, they collide with neutral air molecules. While remaining in the ionizing plasma region, the negative ions have enough energy to ionize neutral molecules upon impact [25]. The newly ionized molecules begin to flow towards the collector sustaining the negative corona. As the electrons begin to reach the end of the ionizing plasma region they begin losing energy [25]. Once reaching the non-ionizing plasma region, molecules no longer possess the amount of energy required to cause ionization due to collision with neutral molecules. Instead, they combine with the neutral molecules resulting in negatively charged molecules [25]. In the unipolar region, negatively charged molecules are colliding with neutral molecules causing a transfer of momentum [25]. As molecules reach the collector, they flow through the ring creating a bulk of steady airflow. Figure 2.2 illustrates the principles and regions of an ionic air moving device using a negative corona configuration.

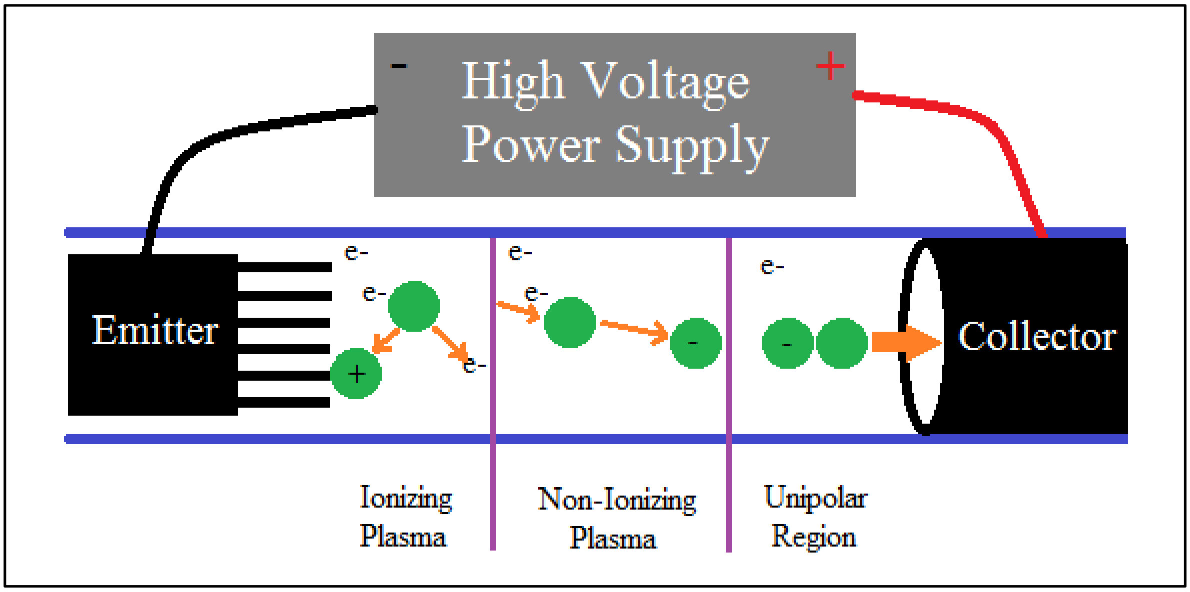

Figure 2.2: Illustration of an ionic air moving device using a negative corona configuration.

2.3 History & Current Technology

A brief description of the former and recent history of ionic air moving devices is provided in this section. The current state of the ionic air moving device is also discussed in this section.

2.3.1 History

Francis Hauksbee [1] is credited with the initial observation of ionic air flow dated back around 1709. Hauksbee conducted a significant experiment involving a steel ring and a piece of flint. The steel ring was attached to a spindle, and the piece of flint was mounted such that the sharp edge faced the steel ring. As Hauksbee turned the spindle, the flint scrapped the steel ring causing sparks as well as airflow through the cylinder. During a 160-year period, a number of scientists observed and reported on the phenomenon of airflow including: Sir Isaac Newton (1718), Michael Faraday (1839), and James Clerk Maxwell (1873).

The first major study focusing on ionic airflow took place around 1899 and was conducted by Arthur Chattock [2]. Chattock's work on airflow involved the relationship between electrified air and plane-parallel electrodes. During the study, it was observed that when high voltage was supplied to a sharp point oriented horizontally to a smooth plate, the particles of air between the point and plate became electrified. Chattock concluded that the particles of air were broken into positive and negative ions. Additionally, it was observed that the velocity of the negative ions exceeded that of the positive ions.

Over the next 60 years, there were a number of scientists who investigated various areas of interest related to ionic airflow. G.W. Trichel [3, 4] is attributed with some of the first detailed documentation of information on coronas. Otmar Stuetzer [5] conducted experiments focused on the theory of ionic drag occurrences and ionic flows amongst gas and liquid as a working fluid.

Between 1961 and 1962, Myron Robinson [6, 7] performed a comprehensive survey of prior work and history related to ionic airflow. A large portion of Robinson's work focused on electric wind and corona discharge. Robinson's research focused on reviving past studies of electric wind for use in new applications such as: applying the wind mechanism to fluid pumps, high-voltage generators, loudspeakers, and thermoelectric converters.

Thong and Weinberg [8] investigated the process of using an electric field as a dispersant of solid and liquid fuels. The study was conducted in efforts to control trajectories of resulting charged particles and the manipulation of their burning. This led to the development of burners operated entirely by electric fields, which draw in and accelerate air from the surroundings using corona discharges in multi-stage ion pumps, the last stage of which atomizes and disperses the fuel. Saxena, Henry, and Podolski [9] conducted experiments on particulate removal from high-temperature high-pressure combustion gases. Particulate removal was observed by means of multiple filtration devices such as: conventional and augmented cyclones, porous metal, fabric, and ceramic membrane filters; fixed, continuously moving, and fluidized-bed granular filters, and electrostatic precipitators. This research contributed to the development of an efficient and economic cleanup system between the combustor and gas turbine. Goldman [10] continued research efforts into the properties of coronas and their specific uses such as: chemical synthesis, surface treatment, electrical insulation, combustion in radical chemistry, and diagnostic techniques of gas.

Ionic air moving devices have been in discussions for use in electronics cooling for the past several years. The idea of replacing fans and blowers for cooling applications offers numerous advantages for industry. Ionic air moving devices contain no physical moving parts and therefore tend to have a longer life span than fans and blowers. The virtually silent operation of ionic air moving devices is another favorable feature compared to the noise associated with fans. Additionally, with the lightweight and self-containing apparatus of the ionic air moving devices design of cooling setup gains flexibility. Although there are several appealing industrial features attributed to ionic air moving devices, their implementation has been slow. This lack of implementation is due to poor efficiency of the current ionic air moving device designs.

The fact that efficiency is the biggest flaw ionic air moving devices possess has fueled an increase into the research and experimentation of ways to increase their efficiency. One solution for increasing the efficiency of these devices is believed to involve the optimization of electrode geometry. Early research on the matter was conducted by Dunn-Rankin, Rickard, and Weinberg

[14, 15, 17]. Their work was a continuation of Robinson's research focusing on the parameters of the ionic air moving devices. Parameters investigated during the study included: pin and ring arrangement, distance variation between electrodes, and ring thickness. By testing multiple parameters, the study resulted in an observation of double the amount of air velocity of previously reported measurements.

Throughout the following years numerous additional studies were conducted focused on ionic wind devices and their efficiency. Rickard's [18] numerical simulations of tubular ion air generation was conducted in 2007. He found that overall system efficiency was increased as distance between electrodes was increased. However, Rickard was only able to observe a 0.1% mechanical efficiency using a ring electrode configuration. Garimella [19] headed investigation into ion wind electronic cooling. He was successful in proving that ionic winds generated from a flat plate configuration indeed increased heat transfer. Garimella verified this finding through experimentation and simulations. Moreau [21] observed the mechanical efficiency of ionic wind in corona discharge. By altering the 2D velocity profile of the corona-generating electrode, he was able to achieve an efficiency of 1.82%. Jewell-Larsen [22, 23] conducted research into electrohydrodynamic (EHD) cooled laptops. He found that smaller electrode devices required less electric potential to produce the same amount of ionic wind as large electrode devices. This finding supported the theoretical potential for miniaturizing ionic air moving devices for purposes of cooling electronics.

2.3.2 Current Technology

In 2010, Kim, Park, Noh, and Hwang [24] conducted research investigating velocity and energy conversion efficiency characteristics of ionic wind generator in a multistage configuration. A six-stage ion wind generator was constructed from stainless steel ring electrodes. The apparatus was constructed in a way that stages ranging from one to six could each be tested. The research concluded that the six-stage ion wind generator produced more volumetric airflow than previously reported in other studies. The results also revealed that the wind velocity and efficiency increased with the square root of number of active stages.

Later in 2010, experimentation and research was conducted by June [26] in continued efforts to increase ionic air moving device efficiency. June utilized a needle type emitter and ring type collector for the research. The study focused on: pin to ring distance, width of the ring, number of ionization sites, and voltage supplied to the electrodes. June's research indicated that when voltage was held constant and distance was increased, airflow decreased and efficiency increased with distance to an optimum. It was also observed that when voltage was increased to a maximum with each increase in ring thickness, or with an increase in number of ionization site, flow increased and efficiency decreased. However, if airflow was held constant as ring thickness or number of ionization sites were increased, voltage needed to maintain the flow decreased and efficiency increased.

In 2011, June [27] conducted further research into ionic air moving devices focusing on measuring efficiency of positive and negative ionic wind devices for comparison to fans and blowers. In the research, a point is made that previous literature has not defined efficiency the way the computer industry defines it for rotary air moving devices such as fans and blowers. The study investigated static efficiency of ionic air moving devices similar to rotary air moving devices. Various emitter to collector distances and ring lengths were evaluated for negative and positive coronas. The results of the experiment illustrated the sensitivity of static efficiency of ionic air moving devices to emitter distance, length of the collector, and polarity of the electrodes. It was observed that parameter settings of emitter to collector distance and collector length that yielded maximum static efficiency did not produce maximum airflow. Additionally, static efficiency of the positive ionic flow was significantly higher than the negative ionic flow for the tested emitter to collector distance and collector length.

In late 2011, research was conducted by Philippe Berard [28] which focused on corona discharges in atmospheric air between a wire and two plates. The research measured ionic wind produced by a wire emitter and two plates using both positive and negative corona. It was concluded that the ionic wind produced by the positive corona was higher than that of the negative corona. A study in 2012 by Kantouna [29] analyzed a cylinder-wire-cylinder electrode configuration during corona discharge. A simulation using an open source Finite Element Method Magnetics software was conducted on a cylinder-wire-cylinder electrode configuration. The findings of the study indicated that increasing the distance between the cylinders resulted in an increase in maximum electric strength and stored energy. Additionally, it was concluded that in the cylinder-wire-cylinder electrode configuration a higher efficiency was observed when the front cylinder was closer to the wire electrode.

Later in 2012, a study conducted by Adrian Ieta [30] focused on corona wind visualization in an asymmetric capacitor using liquid nitrogen. The study utilized the vapors that naturally occur in air, condensed by means of temperature cooling by liquid nitrogen. The cross-sections of the flow were then obtained by light scattering on the water vapors using a fan angle laser sheet. This procedure offered the benefit of not introducing additional particles such as smoke used in previous flow visualization studies. The study resulted in the visualization of corona induced wind, and the effectiveness of using liquid nitrogen for the procedure.

In 2014, June [31] turned his research focus to integrated ionic flow device and heat sink as a fan sink alternative. A small axial fan supplying local airflow to a heat sink was compared to an ionic air moving device incorporated into a heat sink to compare power consumed, while cooling a simulated component to a reasonable temperature. The results of the study concluded that ionic air moving devices used less power than a comparable axial fan to cool a low power electronic component. The airflow output of the ionic air-moving device along with the heat sink provided sufficient capabilities to cool a typical component to a reasonable temperature of 70ºC. The results of this research demonstrate that although standalone ionic air moving devices lack the airflow output and static efficiency required for electronic cooling, their combination to a heat sink improves their overall performance to a level which could cause consideration for implementation.

A study of electrohydrodynamic and wind ions direction produced by positive corona plasma discharge was conducted by Nur [32] in late 2014. The research used a wire to plane electrode configuration for analysis. It was found that the value of characteristic angle of ionic wind flow direction was dependent on electric field intensity and geometry factor. Additionally, the ionic wind flow direction angle value was found to be inversely proportional to the geometry factor, which was defined as the ratio of distance between electrodes and diameter of wire.

In 2015, research on ionic air moving devices was conducted by Adam Henson [33]. His work was a continuation of June's work, which focused on increasing static efficiency of ionic air moving devices. Henson conducted a DOE on parameters of the device including: the number of ionization sites, the distance between the ionization sites and the collector, the height of the collector, and the voltage supplied to the electrodes. He found that the distance between the electrodes, and the voltage were shown to be significant and to have the most effect on the ionic device in terms of airflow. However, additional research into the parameters of ionic air moving devices is required to confirm whether the efficiency can be increased to a level acceptable for use in industrial applications.

Also in 2015, Konstantinos Kiousis [34] conducted research focused on ionic wind generation during positive corona discharge in a wire-cylinder air gap. The intention of the experiment was to determine the relationship between the electric corona discharge current, the ionic wind velocity and the applied high voltage, as well as their dependence on geometrical characteristics of the electrodes. The results showed that the ionic wind velocity is approximately a linear function of the applied voltage and is proportional to the square root of the discharge current. Parametric analysis indicated that increased electrode gap reduced the wind velocity with respect to the applied voltage. The wind velocity increased as cylindrical electrode radius increased. Additionally, increased emitter radius resulted in reduced ionic wind velocity with respect to applied high voltage.

2.4 Summary

This chapter discusses the literature study conducted for this research. Ionic air moving devices are an exciting technology that has been rapidly evolving over the last decade. The most important aspect of investigation associated with ionic air moving devices is the potential of increasing their overall performance to a level that would justify their implementation into the industry of electronics cooling. The purpose of this research is to investigate ionic air moving device geometrical parameters by determining if they have a statistically significant effect of the devices volumetric airflow output and overall static efficiency. Specifically, geometric device parameters investigated include: collector material, collector shape, and number of collectors. Collector materials are investigated at the levels of aluminum, conductive graphite, and copper. Collector shapes varied from cylindrical, conical, and parabolic. The number of collectors used are tested at levels of 4-stage, 6-stage, and 8-stage. Each of the ionic air moving device iterations is tested at distances of 10mm, 15mm, and 20mm. Additionally, each device is supplied with three levels of electric potential. The data is post processed and compared using the maximum volumetric airflow output and maximum static efficiency as the response variables. The experimental set-up, data collection, and data analysis methods used for this study are discussed in Chapter 3. The results of the investigation are presented in Chapter 4. A discussion of the results and how they compare to similar research and expectations are discussed in Chapter 5. The overall conclusions and future scope are discussed in Chapter 6.

CHAPTER 3: METHODOLOGY

This chapter presents and explains the test equipment that has been used for this study. A description of the schedule of testing including the order of specific parameter settings is provided. The method of acquiring data is illustrated. The techniques used for analyzing the final data during this study are also discussed in this chapter.

3.1 Test Equipment

This section provides a brief overview of the equipment used for the purposes of this research. The process of manufacturing the collectors is discussed. A description of the flow bench used to measure the response variables is provided.

3.1.1 Collectors

For the material analysis, three collectors of differing material were used. The collectors were constructed of aluminum, conductive graphite, and copper. Figure 3.1 shows the three collectors of each material used in this research.

Figure 3.1: Collectors used for material analysis constructed from aluminum, conductive graphite, and copper.

Each of the three collectors consists of identical tubular geometries. An outer diameter of 1inch, thickness of 1/16 inch, and height of 1 inch were the dimensions of the collectors.

The shape analysis required three different shaped collectors for testing in this research. The collector shapes selected included cylindrical, conical, and parabolic. Each collector shape was manufactured using the same material of conductive graphite. Figure 3.2 depicts the 3D models of the collectors used for the shape analysis portion of this research.

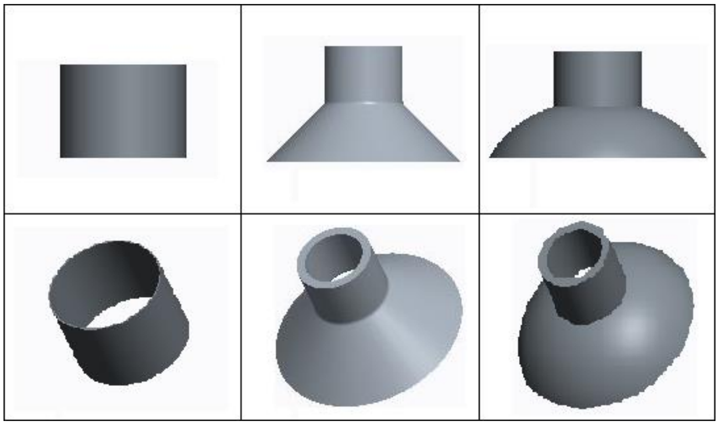

Figure 3.2: Collectors used for shape analysis including cylindrical, conical, and parabolic.

For the analysis of the number of collectors, eight collectors of the same size and shape were required. The collector specifications selected consist of conical shape and conductive graphite material. Additionally, five needles were attached to the front of each of the collectors. A holding apparatus was required to position the collectors in a singular axial orientation. Configurations of 4, 6, and 8 stages of collectors were tested. Figure 3.3 shows the collector and holding apparatus used for the analysis of number of collectors.

Figure 3.3: Collectors and holding apparatus for number of collector analysis.

Collectors for this research were manufactured using a 3D printing process. Collector models were designed using PTC Creo Parametric 3.0. A LulzBot Mini desktop 3D printer with Proto-pasta Conductive Graphite PLA 1.75mm filament was used to print the collectors. Figure 3.4 shows the 3D printing process of the conductive graphite collectors used for this research.

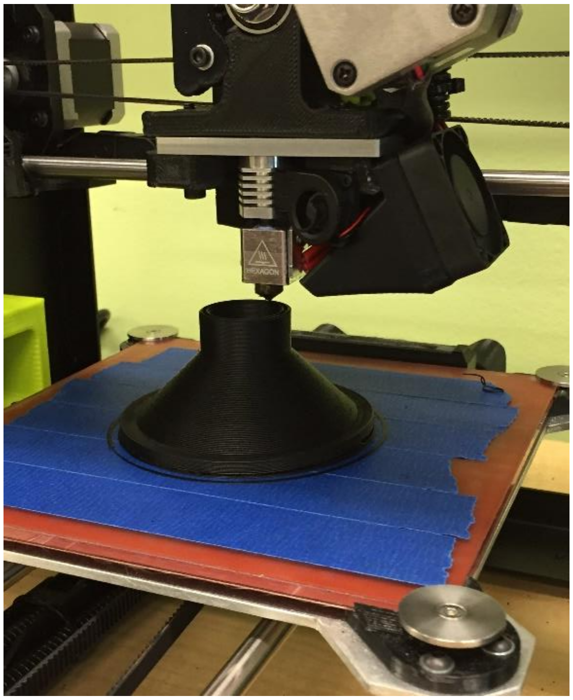

Figure 3.4: LulzBot Mini Desktop 3D printer in the process of printing a collector.

3.1.2 Flow Bench

A flow bench was used to quantify the amount of airflow produced by the ionic air moving devices. Each of the ionic air moving devices were fixed to the back of the flow bench; allowing air to flow into the chamber. With a constant voltage supplied to the device, the static pressure could be adjusted by turning a ball valve, which controlled the amount of air escaping the chamber. When the ball valve was fully closed the pressure in the chamber was at its maximum. Pressure is zero when the ball valve is opened to an extent where the amount of air escaping the chamber is equal to the amount of air entering the chamber. There was a calibrated opening at the exit of the flow bench, which was used for measuring airflow escaping the chamber. Static pressures at the entrance and exit points were measured using two manometers. Figure 3.5 shows the flow bench used for measuring airflow in this research.

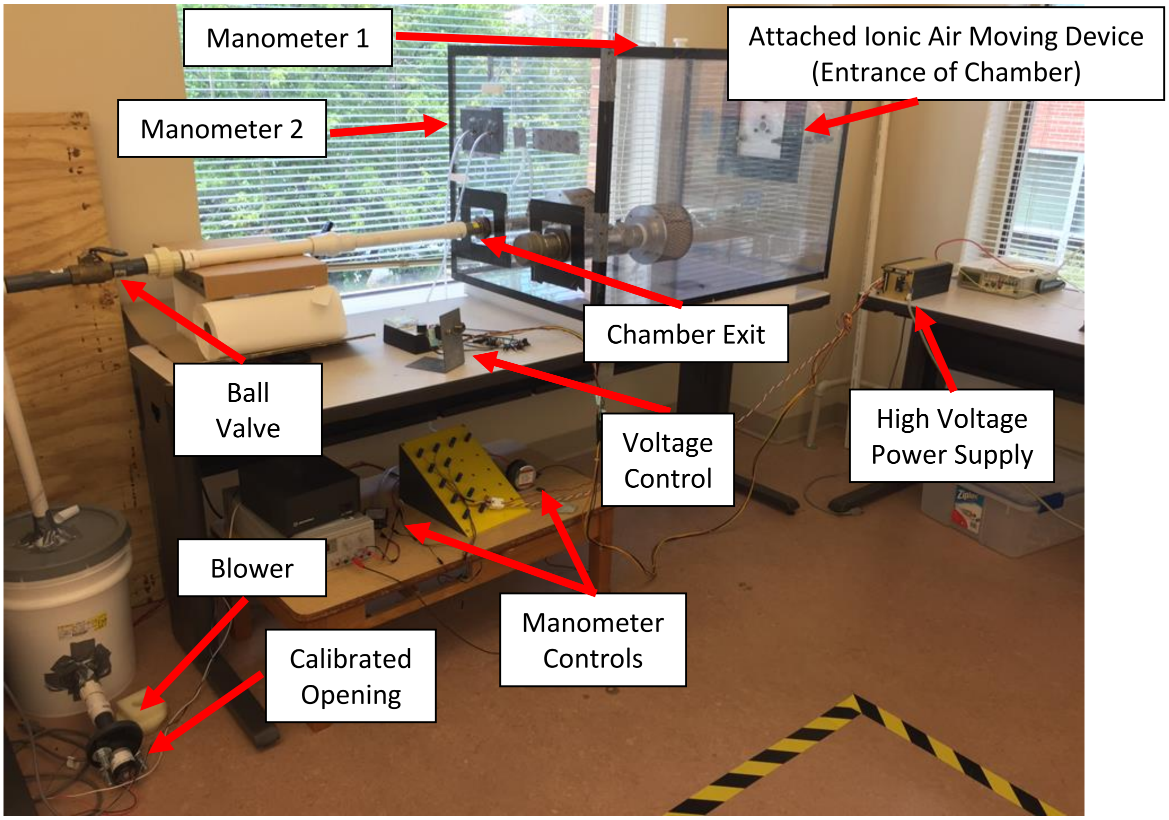

Figure 3.5: Flowbench used for quantifying airflow produced by ionic air moving devices.

3.1.3 High Voltage Power Supply

The electric potential required for ionic air moving device operation was supplied to the electrodes using an Acopian® NO20HA1.5M high voltage power supply single phase output 0-20,000 volts DC. The power supply was wired to a positive and negative electrical lead. The negative lead was attached to the emitter electrode. The positive lead was attached to the collector electrode. Using this configuration, the ionic air moving device was operating using a negative corona. Figure 3.6 shows the high voltage power supply used for this research and how it was attached to the ionic air moving devices during testing.

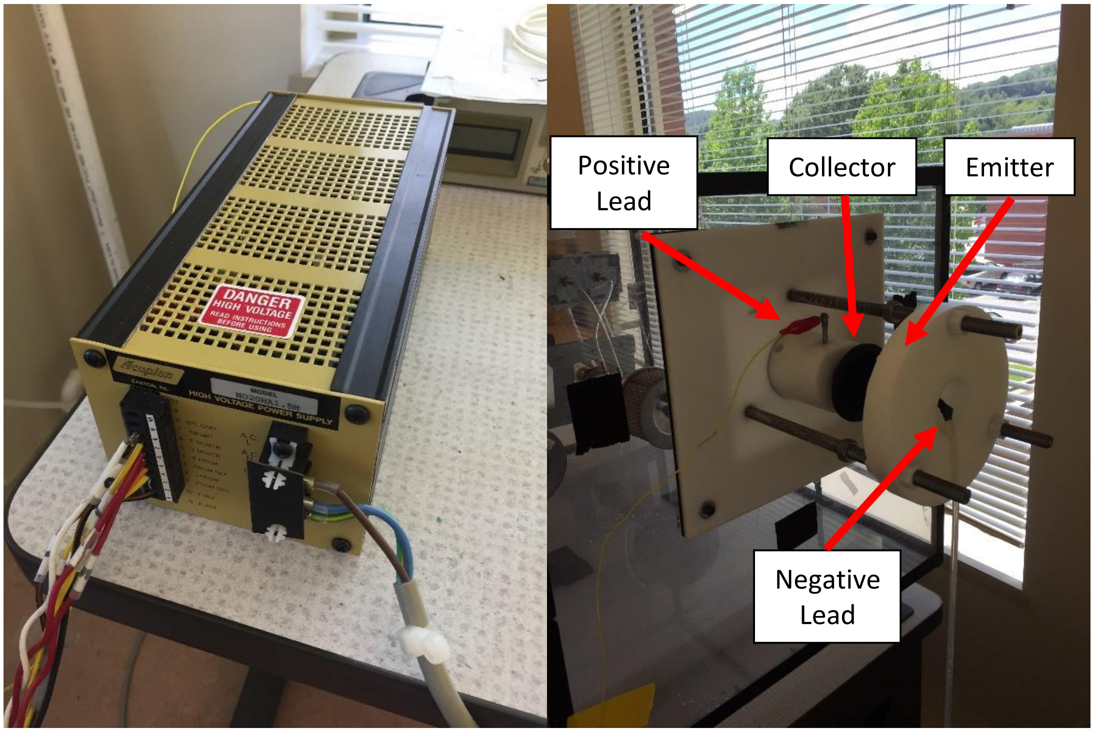

Figure 3.6: Acopian NO20HA 1.5M high voltage power supply and method of attaching electrical leads to ionic air moving devices during testing.

3.2 Schedule of Test

A total of nine different ionic air moving devices were tested during this research. The emitter used for each device was an array of five needles attached to a cylindrical aluminum base. For the material analysis, three devices were used which consisted of cylindrical collectors varying in materials included: aluminum, conductive graphite, and copper. For the shape analysis, three device collectors were used constructed from conductive graphite and differing in shapes of: cylindrical, conical, and parabolic. For the multi-stage analysis, eight collectors were built from conductive graphite with a conical shape. These collectors had five needles affixed to the exit side, which enabled them to serve as an emitter and collector when arranged in series. Multi-stage ionic air moving devices were tested at levels of four, six, and eight stages of collectors. Each of the nine devices were tested at three emitter-to-collector distances included:

10mm, 15mm, and 20mm. At each of the three distances, devices were tested at three different voltages, which varied depending on the level of electric potential the device could withstand without the occurrence of arching. Table 3.1 shows each of the 81 individual tests conducted in this research separated by collector material, collector shape, number of collectors, supplied voltage, and electrode gap.

Table 3.1: Schedule of conducted test by device parameters and settings.

Aluminum (Cylinder)			Conductive Graphite (Cylinder)			Copper (Cylinder)		
10mm	15mm	20mm	10mm	15mm	20mm	10mm	15mm	20mm
7,500 V	10,000 V	10,000 V	7,500 V	10,000 V	10,000 V	7,500 V	10,000 V	10,000 V
8,750 V	12,500 V	15,000 V	8,750 V	12,500 V	15,000 V	8,750 V	12,500 V	15,000 V
10,000 V	15,000 V	17,500 V	10,000 V	15,000 V	17,500 V	10,000 V	15,000 V	17,500 V

Conductive Graphite (Cylinder)			Conductive Graphite (Conical)			Conductive Graphite (Parabolic)		
10mm	15mm	20mm	10mm	15mm	20mm	10mm	15mm	20mm
11,000 V	15,000 V	17,500 V	11,000 V	15,000 V	17,500 V	11,000 V	15,000 V	17,500 V
12,000 V	16,750 V	19,500 V	12,000 V	16,750 V	19,500 V	12,000 V	16,750 V	19,500 V
13,000 V	18,000 V	20,750 V	13,000 V	18,000 V	20,750 V	13,000 V	18,000 V	20,750 V

Conductive Graphite (4-Stage)			Conductive Graphite (6-Stage)			Conductive Graphite (8-Stage)		
10mm	15mm	20mm	10mm	15mm	20mm	10mm	15mm	20mm
8,500 V	10,000 V	10,000 V	8,500 V	10,000 V	10,000 V	8,500 V	10,000 V	10,000 V
10,000 V	11,500 V	13,000 V	10,000 V	11,500 V	13,000 V	10,000 V	11,500 V	13,000 V
11,500 V	13,000 V	16,000 V	11,500 V	13,000 V	16,000 V	11,500 V	13,000 V	16,000 V

3.2 Data Acquisition Method

A flow bench was used to quantify the amount of airflow produced by the ionic air moving devices. The devices were fixed to the back of the flow bench; moving air into the chamber. With a constant voltage supplied to the device, the static pressure was adjusted by a ball valve, which controlled the amount of air escaping the chamber using a blower at the calibrated opening. When the ball valve was closed, the pressure in the chamber was at its maximum. Pressure was zero when the ball valve was opened to an extent where the amount of air escaping the chamber was equal to the amount of air entering. There was a calibrated opening at the exit of the flow bench, which was used for measuring airflow. Static pressures at the entrance and exit points were measured using two manometers. An Agilent® E3620A dual output DC power supply was used to supply power to the manometers, while a Motorola® HPN1007A 13.6 VDC power supply was used to power the blower [33]. A Meriam® 50MW20-1F laminar flow element was connected to the flow bench in order to measure the volumetric air when the ionic air moving device was generating air flow [33]. A Dwyer® HADP-BV-08-A1 high accuracy differential pressure transmitter and a Dwyer® 616-3 differential pressure transmitter (manometers) were connected to the laminar flow element by tubing in order to measure static pressure and volumetric airflow [33]. A National Instruments® NI USB-6008 DAQ (data acquisition unit) was attached to read voltage and current values output from the manometers [33]. A LabVIEW® program was created to process the value readings from the DAQ.

LabVIEW® (Laboratory Virtual Instrument Engineering Workbench) is a program that uses G programming language to allow the user to read measurements and data, analyze data, and present results. A LabVIEW® program was developed by Michael June [25, 26, 27, 31] that displayed values of: static pressure, current, pressure, volumetric flow rate, power supply voltage, and power supply current. The program was comprised of a sub-program referred to as a SubVI and the primary program called the MainVI. The SubVI and MainVI have a block diagram comprised of graphical icons and wiring configuration that perform the graphical method of programming and a front panel which allows user input for monitoring and control. Figures 3.7, 3.8, and 3.9 show the LabVIEW® MainVI's and SubVI's used in this research.

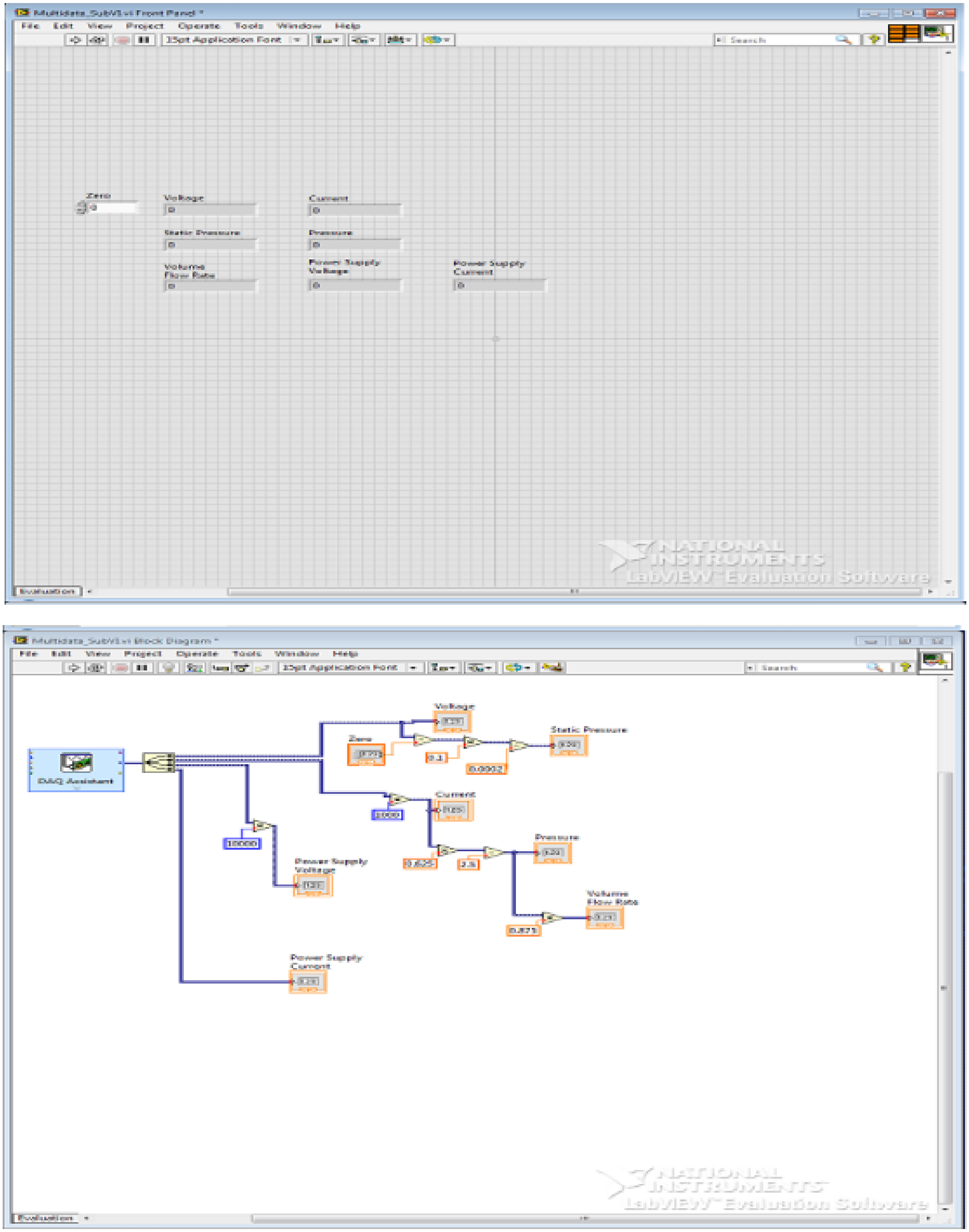

Figure 3.7: SubVI Front Panel and Block Diagram

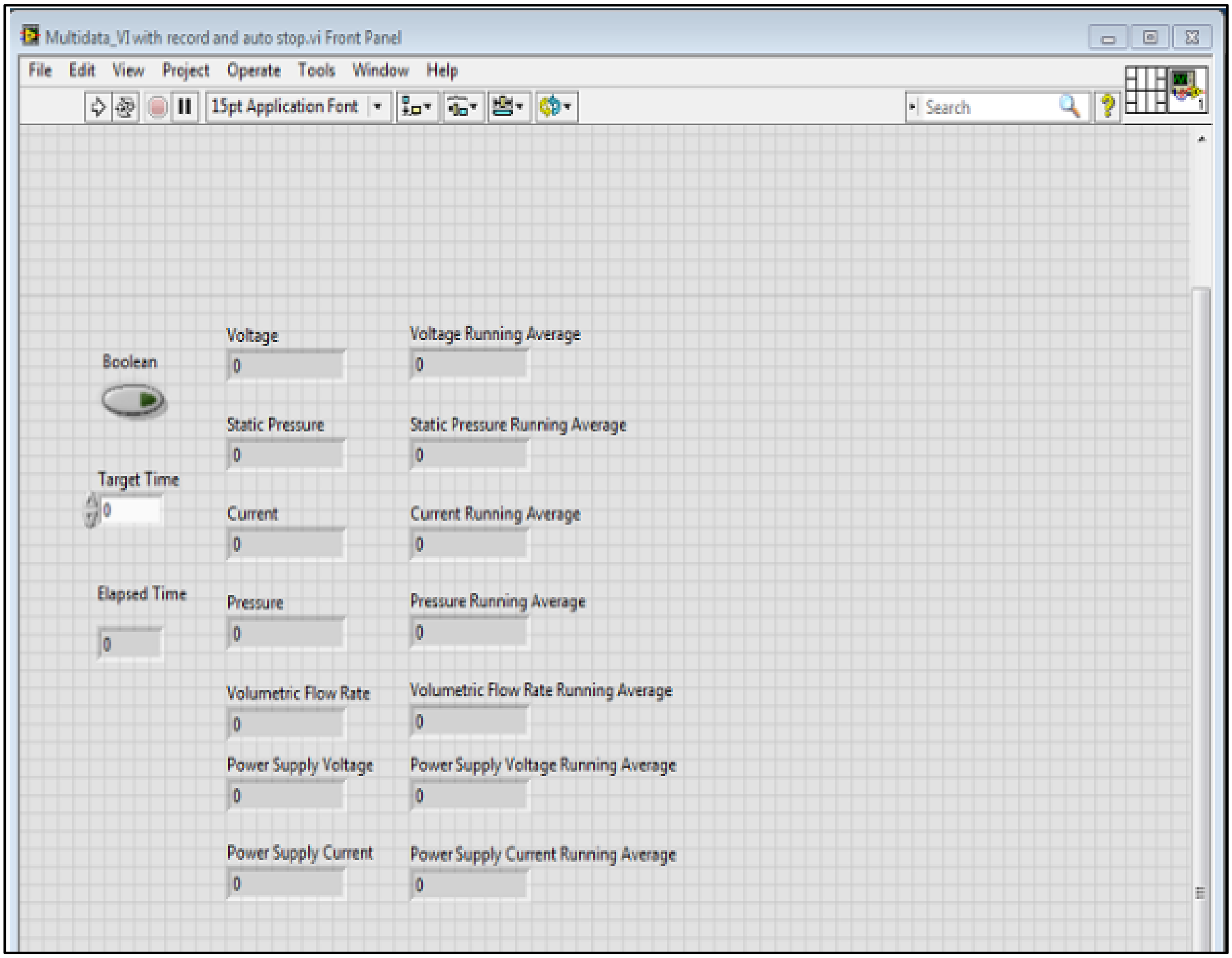

Figure 3.8: MainVI Front Panel

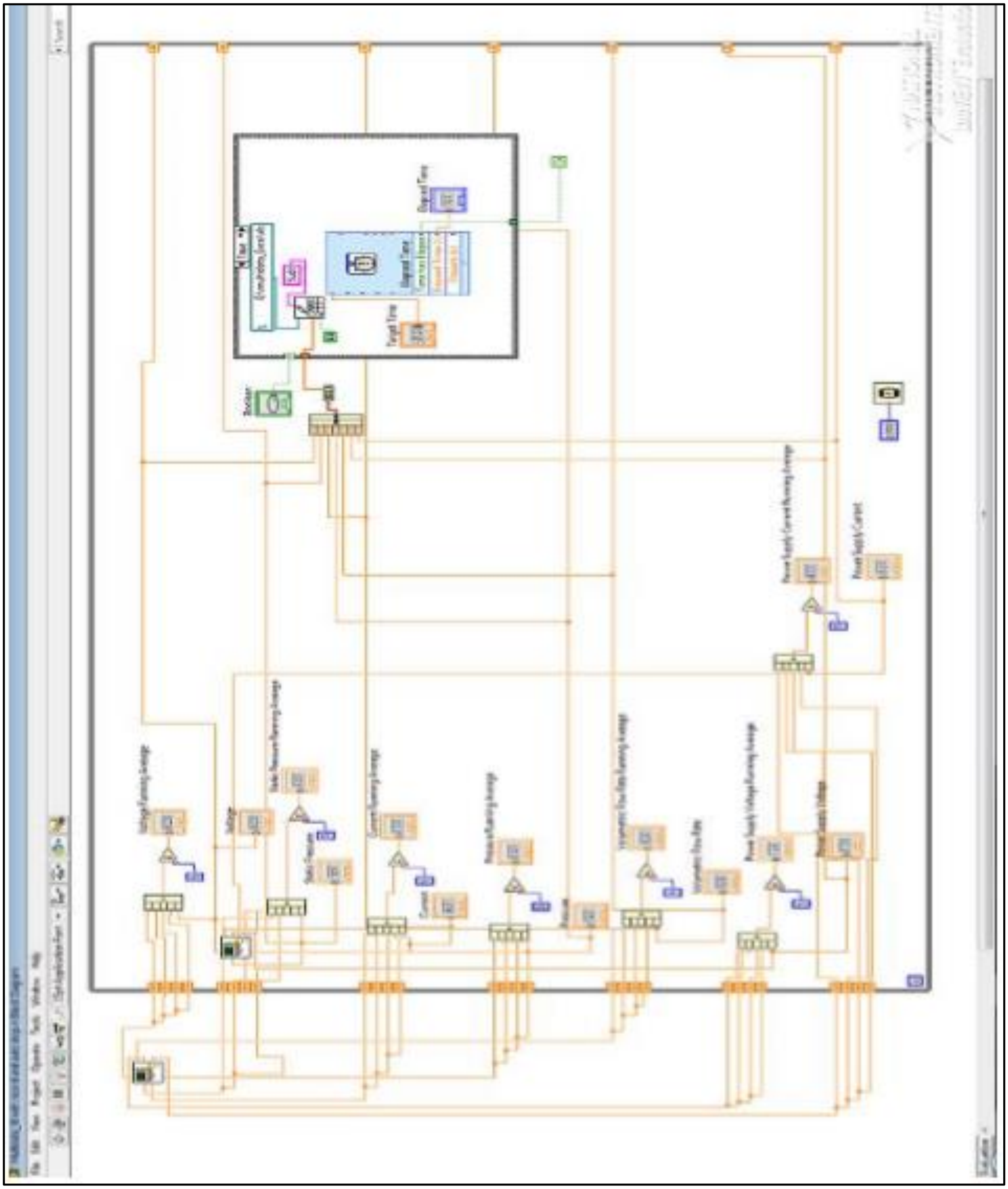

Figure 3.9: Main VI Block Diagram

3.4 Data Analysis Method

This section provides a brief overview of the data analysis methods used for the results of this research. The logic and set-up of the DOE used to analyze maximum volumetric airflow output is discussed. A description of the method used for analyzing maximum static efficiency is provided.

3.4.1 Maximum Volumetric Airflow Output

A maximum value of volumetric airflow output (Q) was recorded for each of the 81 individual device parameters and settings. Each device, at every setting, was then replicated two more times. Meaning, a total of three runs were completed for each of the 81 subgroups. Table 3.2 shows the tests conducted for maximum volumetric airflow analysis.

Table 3.2: Test and runs conducted for maximum volumetric airflow analysis.

Material Analysis				Material Analysis				Material Analysis			
10 mm	Aluminum	Conductive Graphite	Copper	**15 mm**	Aluminum	Conductive Graphite	Copper	**20 mm**	Aluminum	Conductive Graphite	Copper
7,500 V	Run 1	Run 1	Run 1	10,000 V	Run 1	Run 1	Run 1	10,000 V	Run 1	Run 1	Run 1
	Run 2	Run 2	Run 2		Run 2	Run 2	Run 2		Run 2	Run 2	Run 2
	Run 3	Run 3	Run 3		Run 3	Run 3	Run 3		Run 3	Run 3	Run 3
8,750 V	Run 1	Run 1	Run 1	12,500 V	Run 1	Run 1	Run 1	15,000 V	Run 1	Run 1	Run 1
	Run 2	Run 2	Run 2		Run 2	Run 2	Run 2		Run 2	Run 2	Run 2
	Run 3	Run 3	Run 3		Run 3	Run 3	Run 3		Run 3	Run 3	Run 3
10,000 V	Run 1	Run 1	Run 1	15,000 V	Run 1	Run 1	Run 1	17,500 V	Run 1	Run 1	Run 1
	Run 2	Run 2	Run 2		Run 2	Run 2	Run 2		Run 2	Run 2	Run 2
	Run 3	Run 3	Run 3		Run 3	Run 3	Run 3		Run 3	Run 3	Run 3

Shape Analysis				Shape Analysis				Shape Analysis			
10 mm	Cylindrical	Conical	Parabolic	**15 mm**	Cylindrical	Conical	Parabolic	**20 mm**	Cylindrical	Conical	Parabolic
11,000 V	Run 1	Run 1	Run 1	15,000 V	Run 1	Run 1	Run 1	17,500 V	Run 1	Run 1	Run 1
	Run 2	Run 2	Run 2		Run 2	Run 2	Run 2		Run 2	Run 2	Run 2
	Run 3	Run 3	Run 3		Run 3	Run 3	Run 3		Run 3	Run 3	Run 3
12,000V	Run 1	Run 1	Run 1	16,750 V	Run 1	Run 1	Run 1	19,500 V	Run 1	Run 1	Run 1
	Run 2	Run 2	Run 2		Run 2	Run 2	Run 2		Run 2	Run 2	Run 2
	Run 3	Run 3	Run 3		Run 3	Run 3	Run 3		Run 3	Run 3	Run 3
13,000 V	Run 1	Run 1	Run 1	18,000 V	Run 1	Run 1	Run 1	20,750 V	Run 1	Run 1	Run 1
	Run 2	Run 2	Run 2		Run 2	Run 2	Run 2		Run 2	Run 2	Run 2
	Run 3	Run 3	Run 3		Run 3	Run 3	Run 3		Run 3	Run 3	Run 3

Multi-Stage Analysis				Multi-Stage Analysis				Multi-Stage Analysis			
10 mm	4-Stage	6-Stage	8-Stage	**15 mm**	4-Stage	6-Stage	8-Stage	**20 mm**	4-Stage	6-Stage	8-Stage
8,500 V	Run 1	Run 1	Run 1	10,000 V	Run 1	Run 1	Run 1	10,000 V	Run 1	Run 1	Run 1
	Run 2	Run 2	Run 2		Run 2	Run 2	Run 2		Run 2	Run 2	Run 2
	Run 3	Run 3	Run 3		Run 3	Run 3	Run 3		Run 3	Run 3	Run 3
10,000 V	Run 1	Run 1	Run 1	11,500 V	Run 1	Run 1	Run 1	13,000 V	Run 1	Run 1	Run 1
	Run 2	Run 2	Run 2		Run 2	Run 2	Run 2		Run 2	Run 2	Run 2
	Run 3	Run 3	Run 3		Run 3	Run 3	Run 3		Run 3	Run 3	Run 3
11,500 V	Run 1	Run 1	Run 1	13,000 V	Run 1	Run 1	Run 1	16,000 V	Run 1	Run 1	Run 1
	Run 2	Run 2	Run 2		Run 2	Run 2	Run 2		Run 2	Run 2	Run 2
	Run 3	Run 3	Run 3		Run 3	Run 3	Run 3		Run 3	Run 3	Run 3

For the initial analysis, a two factor two level DOE (design of experiments) was conducted on the high and low settings of each device. A total of nine initial DOE's were conducted. For the material analysis, copper was the low setting and aluminum was the high setting. For the shape analysis, cylindrical was the low setting and conical was the high setting. For the multi-stage analysis, 4-stage was the low setting and 8-stage was the high setting. Table 3.3 shows the test order selected for the initial DOE analysis.

Table 3.3: Order of High and low settings selected for the initial DOE analysis.

10 mm			**15 mm**			**20 mm**		
	-	+		-	+		-	+
	Copper	Aluminum		Copper	Aluminum		Copper	Aluminum
7,500 V	Run 1	Run 1	10,000 V	Run 1	Run 1	10,000 V	Run 1	Run 1
	Run 2	Run 2		Run 2	Run 2		Run 2	Run 2
	Run 3	Run 3		Run 3	Run 3		Run 3	Run 3
10,000 V	Run 1	Run 1	15,000 V	Run 1	Run 1	17,500 V	Run 1	Run 1
	Run 2	Run 2		Run 2	Run 2		Run 2	Run 2
	Run 3	Run 3		Run 3	Run 3		Run 3	Run 3
	-	+		-	+		-	+
	Cylindrical	Conical		Cylindrical	Conical		Cylindrical	Conical
11,000 V	Run 1	Run 1	15,000 V	Run 1	Run 1	17,500 V	Run 1	Run 1
	Run 2	Run 2		Run 2	Run 2		Run 2	Run 2
	Run 3	Run 3		Run 3	Run 3		Run 3	Run 3
13,000 V	Run 1	Run 1	18,000 V	Run 1	Run 1	20,750 V	Run 1	Run 1
	Run 2	Run 2		Run 2	Run 2		Run 2	Run 2
	Run 3	Run 3		Run 3	Run 3		Run 3	Run 3
	-	+		-	+		-	+
	4-Stage	8-Stage		4-Stage	8-Stage		4-Stage	8-Stage
8,500 V	Run 1	Run 1	10,000 V	Run 1	Run 1	10,000 V	Run 1	Run 1
	Run 2	Run 2		Run 2	Run 2		Run 2	Run 2
	Run 3	Run 3		Run 3	Run 3		Run 3	Run 3
11,500 V	Run 1	Run 1	13,000 V	Run 1	Run 1	16,000 V	Run 1	Run 1
	Run 2	Run 2		Run 2	Run 2		Run 2	Run 2
	Run 3	Run 3		Run 3	Run 3		Run 3	Run 3

Several methods of computation for the DOE analyses were completed for purposes of verification. The first method was the use of the statistical analysis software Minitab®. A full factorial design was selected, which means each experimental unit took on all possible combinations of levels across all factors. A total of nine separate DOE's were conducted which were two factor two level. The relationship between factors and levels is analyzed in the results output by Minitab®. Minitab® produces analysis of variance charts and graphs used to identify which factors possess a statistically significant effect on ionic air moving device volumetric airflow output.

A summary ANOVA table was formulated by Minitab® displaying the significant statistical variables associated with DOE analysis. The values of the statistics that form this ANOVA table are evaluated to determine which factors had an effect on ionic air moving device volumetric airflow output. Significance is determined by comparing the calculated p-value to the pre-determined alpha value. A generally accepted alpha value of 0.05 was used for this research. Using this alpha value, the findings can be stated with a 95% confidence level. A p-value lower than the alpha value for a specific factor indicates the factor has a statically significant effect on the response variable. A p-value higher than the alpha value indicates the factor has no statistically significant effect on the response variable. Additionally, Minitab® generates a regression equation that can be used in the future for estimation of a devices performance based on what factors are used.

The second method for conducting the DOE's was manual calculations using Microsoft Excel. A spreadsheet was created to calculate the values that make up the summary ANOVA table. The effect value for each factor was also calculated in order to determine how much of an impact significant factors were at determining the response variable. Table 3.4 shows the formulas used for the manual calculations of the variables that form the summary ANOVA table.

Table 3.4: Manual calculation formulas for a 2 factor 2 level summary ANOVA table.

ANOVA Summary Calculations For a 2 Factor 2 Level DOE					
SOURCE	SS	df	MS	F	P- value
A	SS_A	a-1	SS_A / a-1	MS_A / MS_{ERROR}	fdist(F_A , df_A , df_{ERROR})
B	SS_B	b-1	SS_B / b-1	MS_B / MS_{ERROR}	fdist(F_B , df_B , df_{ERROR})
AB	SS_{AB}	(a-1)(b-1)	SS_{AB} / (a-1)(b-1)	MS_{AB} / MS_{ERROR}	fdist(F_{AB} , df_{AB} , df_{ERROR})
ERROR	SS_{ERROR}	ab(n-1)	SS_{ERROR} / abc(n-1)		
TOTAL	SSTO	abn-1			

The third and final method for verifying the results yielded from the previous methods was the use of the data analysis toolbox in Microsoft Excel. In this toolbox, an option for a two factor ANOVA with replication was offered. This option calculates the same summary ANOVA table produced by Minitab® and the manual calculations. However, this method does not calculate a regression equation or effect values. It was simply a quick way to verify the values of the summary ANOVA table calculated by the previous methods.

Following the nine initial DOE's, the results were reviewed. If a factor of collector material, collector shape, or number of collectors were found to be statistically significant, further analysis would be required. A DOE of the medium and high parameter setting would need to be conducted to determine if a statistically significant difference occurred between the two. The same process for conducting a two factor two level DOE as previous analysis would be completed. For factors that were found to be statistically insignificant, no further testing would be required.

3.4.2 Maximum Static Efficiency

For each ionic air moving device tested, a data set was collected over an incremental range from zero pressure to maximum pressure. At zero pressure, the ball valve attached to the flow bench was opened to an extent where the total amount of air entering the chamber was allowed to exit through the calibrated opening. Pressure was then incrementally decreased by one inH2O until zero volumetric airflow was observed, which indicated maximum pressure. At maximum pressure, the ball value attached to the flow bench was fully closed preventing any air from escaping the chamber. Three response variables were collected at each increment of pressure including: volumetric airflow, voltage, and current. Static efficiency was calculated by the following equation in which: Q represents volumetric airflow, P represents static pressure, V represents voltage, and I represents current.

$$\eta = \frac{Q\ x\ P}{V\ x\ I}$$

A graph of each data set was produced using pressure as the x-axis and efficiency as the y-axis. Figure 3.10 shows an example of an ionic air moving device efficiency graph produced in this research. Plots of pressure vs. flow rate and pressure vs. efficiency for all test configurations are shown in Appendix B.

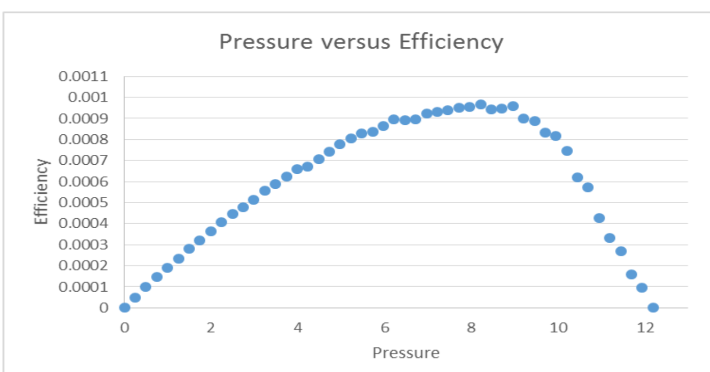

Figure3.10: Example of a pressure versus efficiency graph.

It can be inferred, from the trend of the data points shown in figure 3.10, that the ionic air moving device efficiency could be modeled as a polynomial curve. A best-fit polynomial curve could be formulated for each device tested and the maximum of that curve would represent the maximum efficiency for that specific device. The reason a model was required was due to the uncertainty of the maximum peak value because of fluctuation in the raw data. A program was written in Matlab® to perform the previously mentioned operations on the collected efficiency data for each tested device. Additionally, the Matlab® code would plot the data points with the corresponding polynomial curve and display the calculated maximum value. A summary table with the calculated maximum efficiency value for each device was also created.

Unlike the volumetric airflow data, a series of DOE's was not a practical method of analysis for the efficiency data. A DOE and ANOVA require at least two replications of each test in order to be properly conducted. Instead, a conclusion was determined based on the individual recorded values of efficiency for each of the completed tests. A visual overlap chart was created for the material, shape, and multi-stage analysis to illustrate device performance in relation to distance and voltage.

CHAPTER 4: EXPERIMENTAL RESULTS

This chapter briefly discusses the experimental setup and results obtained from testing. Results from the DOE analysis of the volumetric airflow output are provided. Values and charts formulated from the efficiency analysis are also presented. Some discussion on the post-processed results is included in this chapter.

4.1 Experimental Setup – Maximum Volumetric Airflow Output

A series of nine DOE and ANOVA tests were selected as the method for analyzing the maximum volumetric airflow output data. The DOEs were initially setup and performed in Minitab®. The first steps of the procedure for DOE setup in Minitab® were to select Stat in the top toolbar, DOE in the pull-down menu, Factorial in the pull-down menu, and Create Factorial Design in the final pull-down menu. Figure 4.1 shows an illustration of the setup selection options and location in Minitab®.

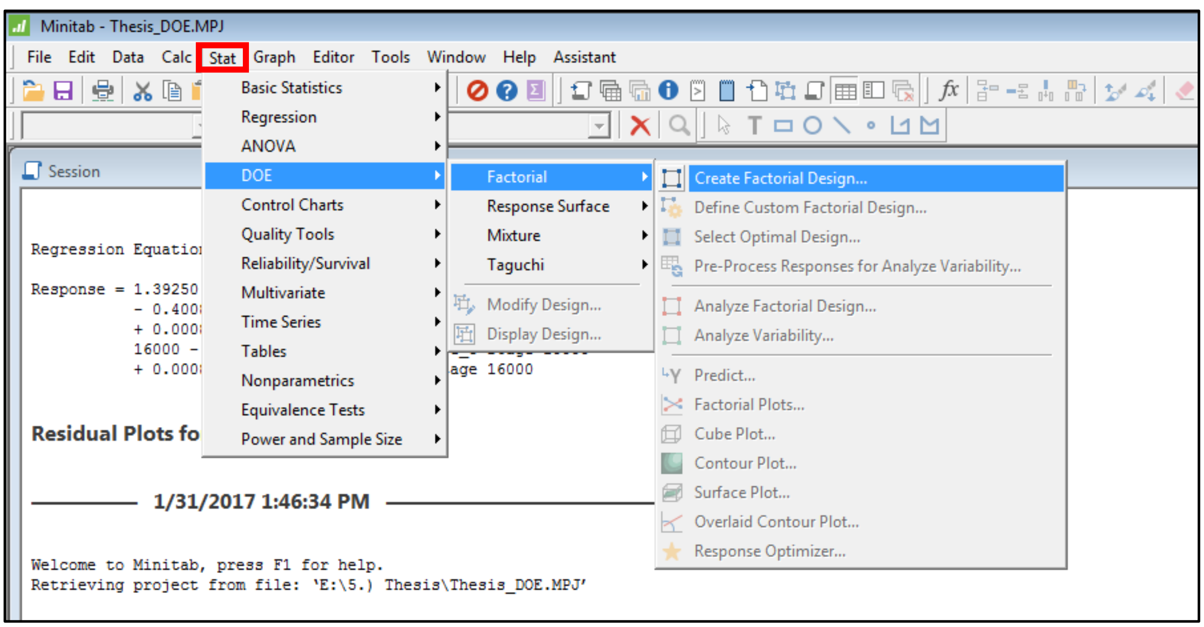

Figure 4.1: DOE Setup Option Menu in Minitab®.

After selecting Create factorial design, a new window appears listing different options for types of designs. The design selected for this research was a full factorial design. Next, the number of factors being analyzed were selected, which was two for this research (material and voltage, shape and voltage, or multi-stage and voltage). The next step was to click on the design tab which opened an options menu. In this menu, name and number of levels were assigned for the factors being tested. For the initial DOE's, two levels of each factor were tested for significance (high and low settings). Additionally, the numbers of replicates of each test were specified in this menu. Three replicates of each test were completed for this research. Figure 4.2 shows the factorial design option window.

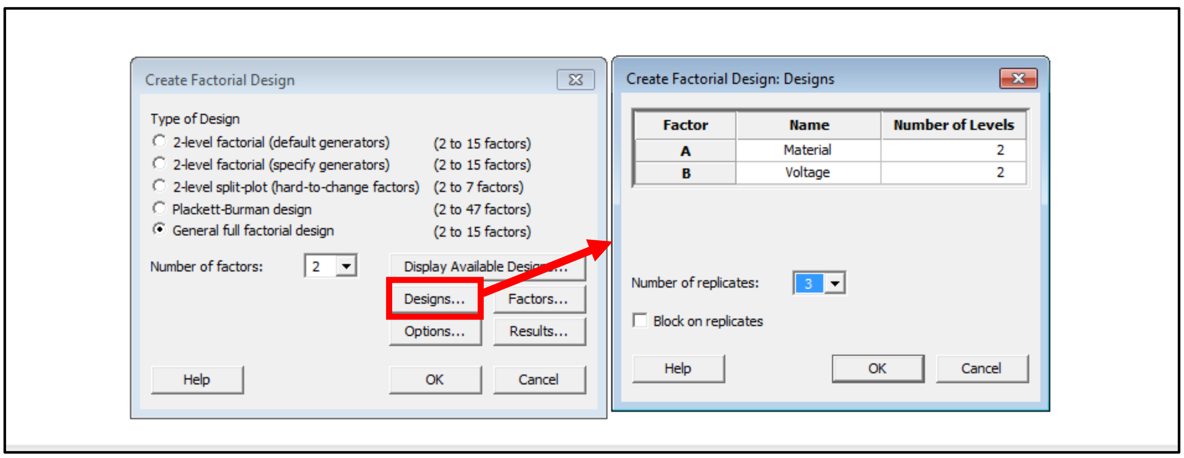

Figure 4.2: Factorial Design Factor Design Windows in Minitab®.

The next step was to assign factors with corresponding level classifications. Click on the button labeled factors to open the factorial design-factor specification window. From this window, factors were assigned a type depending on whether their levels were a numeric value or text classification. Level values and classifications were also typed in this window. Figure 4.3 shows the factorial design-factor specification window.

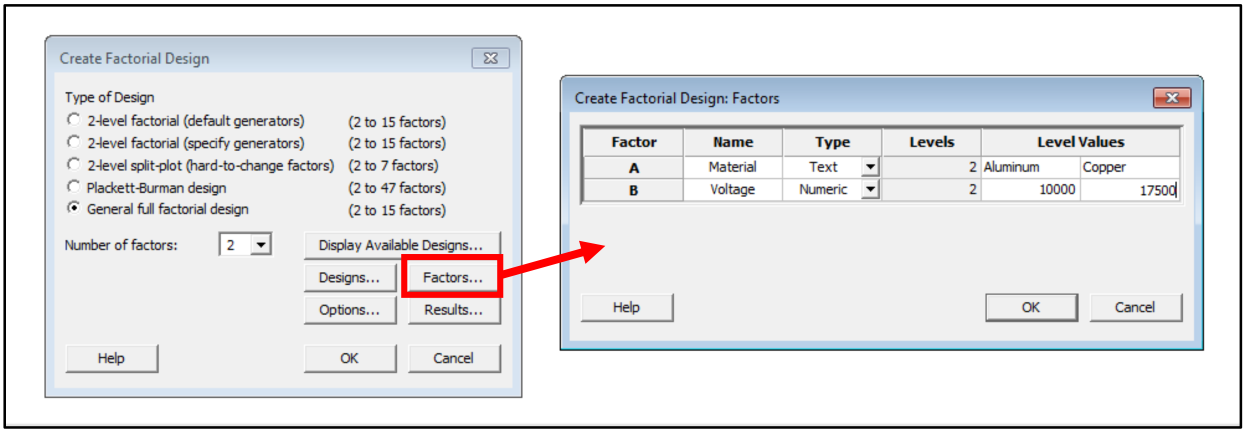

Figure 4.3: Factorial Design Factor Specification Window in Minitab®.

The last step for setting up the DOE in Minitab® was to remove the default setting of randomized runs. Click on the options button in the factorial design main window. A factorial design option window is opened. Deselect the randomize runs box. Figure 4.4 shows the factorial design option window in Minitab®.

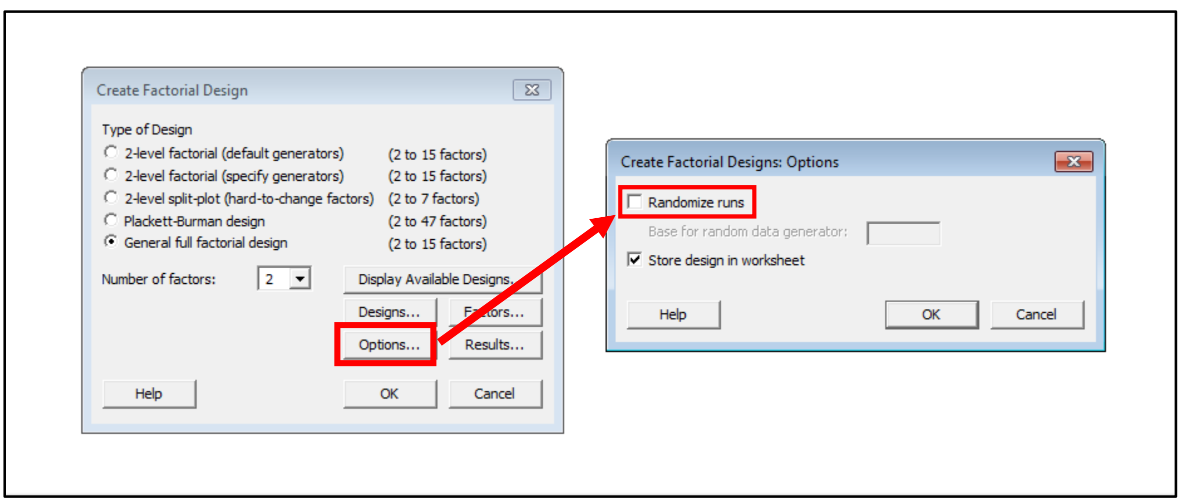

Figure 4.4: Factorial Design Options Window in Minitab®.

After verifying the discussed settings, press the ok button to generate the DOE matrix. To complete the DOE matrix, a response value column needed to be included. Table 4.1 shows the results of each test and replication conducted for maximum volumetric airflow output measured in cfm (ft^3/min).

Table 4.1: Results - Maximum Volumetric Airflow Output.

	Material Analysis Data			Shape Analysis Data			Multi-Stage Analysis Data		
	Aluminum	Conductive Graphite	Copper	Cylindrical	Conical	Parabolic	Four Stage	Six Stage	Eight Stage
10 mm	7,500 V			11,000 V			8,500 V		
	1.12	1.041	1.04	1.79	2.09	2.01	1.39	1.41	1.42
	1.08	1.03	0.99	1.75	2.09	1.99	1.36	1.39	1.38
	1.11	1.01	1.02	1.76	2.06	1.97	1.39	1.38	1.41
10 mm	8,750 V			12,000 V			10,000 V		
	1.47	1.43	1.35	2.05	2.26	2.25	1.74	1.76	1.76
	1.47	1.4	1.33	2.02	2.25	2.21	1.71	1.73	1.72
	1.45	1.41	1.31	2.04	2.22	2.22	1.72	1.74	1.74
10 mm	10,000 V			13,000 V			11,500 V		
	1.71	1.73	1.66	2.31	2.58	2.55	2.02	2.02	2.03
	1.68	1.7	1.63	2.29	2.54	2.52	1.99	2.02	1.98
	1.69	1.73	1.65	2.29	2.57	2.55	2.01	1.98	1.99
15 mm	10,000 V			15,000 V			10,000 V		
	1.19	1.27	1.12	2.27	2.52	2.5	1.27	1.26	1.28
	1.16	1.23	1.12	2.23	2.52	2.46	1.24	1.24	1.22
	1.18	1.24	1.09	2.26	2.49	2.48	1.25	1.24	1.25
15 mm	12,500 V			16,750 V			11,500 V		
	1.88	1.81	1.71	2.45	2.9	2.81	1.56	1.55	1.56
	1.84	1.77	1.66	2.42	2.87	2.76	1.51	1.53	1.52
	1.86	1.8	1.69	2.42	2.88	2.77	1.54	1.53	1.55
15 mm	15,000 V			18,000 V			13,000 V		
	2.09	2.27	2.01	2.62	3.15	2.92	1.79	1.78	1.77
	2.06	2.27	1.99	2.61	3.11	2.92	1.77	1.75	1.74
	2.09	2.25	1.99	2.58	3.12	2.88	1.78	1.75	1.76
20 mm	10,000 V			17,500 V			10,000 V		
	1.064	0.91	0.8	2.08	2.63	2.34	1.01	1.01	0.99
	1.05	0.88	0.8	2.05	2.59	2.31	0.98	0.99	0.99
	1.03	0.89	0.78	2.04	2.61	2.31	1.01	0.98	0.97
20 mm	15,000 V			19,500 V			13,000 V		
	1.82	1.74	1.52	2.23	2.89	2.71	1.4	1.42	1.39
	1.79	1.74	1.49	2.19	2.88	2.68	1.37	1.39	1.38
	1.8	1.71	1.52	2.22	2.86	2.68	1.38	1.41	1.38
20 mm	17,500 V			20,750 V			16,000 V		
	2.08	2.08	1.87	2.43	3.14	2.88	1.81	1.8	1.81
	2.07	2.08	1.84	2.38	3.14	2.84	1.79	1.77	1.79
	2.05	2.06	1.86	2.41	3.12	2.85	1.8	1.78	1.76

A DOE matrix was generated for each of the nine individual analyses that needed to be performed. A response value column representing maximum volumetric airflow output was creating corresponding a value to each factor and level. Table 4.2 shows one of the nine DOE matrices created in Minitab®.

Table 4.2: Pre-Analysis DOE Matrix in Minitab®.

Material Analysis @ 10mm (-1 Copper : +1 Aluminum) (-1 7,500 V : +1 10,000 V)						
StdOrder	RunOrder	PtType	Blocks	Material	Voltage	Response
1	1	1	1	Copper	7500	1.04
2	2	1	1	Copper	10000	1.66
3	3	1	1	Aluminum	7500	1.12
4	4	1	1	Aluminum	10000	1.71
5	5	1	1	Copper	7500	0.99
6	6	1	1	Copper	10000	1.63
7	7	1	1	Aluminum	7500	1.08
8	8	1	1	Aluminum	10000	1.68
9	9	1	1	Copper	7500	1.02
10	10	1	1	Copper	10000	1.65
11	11	1	1	Aluminum	7500	1.11
12	12	1	1	Aluminum	10000	1.69

Once the data was organized, the final step was to analyze the factorial design. Click on the Stat button on the top toolbar in Minitab®. Select DOE in the pull-down menu. Next, select factorial in the following pull-down menu. Then, select analyze factorial design in the final pull-down menu. Figure 4.5 shows the correct pull-down menu tabs to select for analyzing the factorial design in Minitab®.

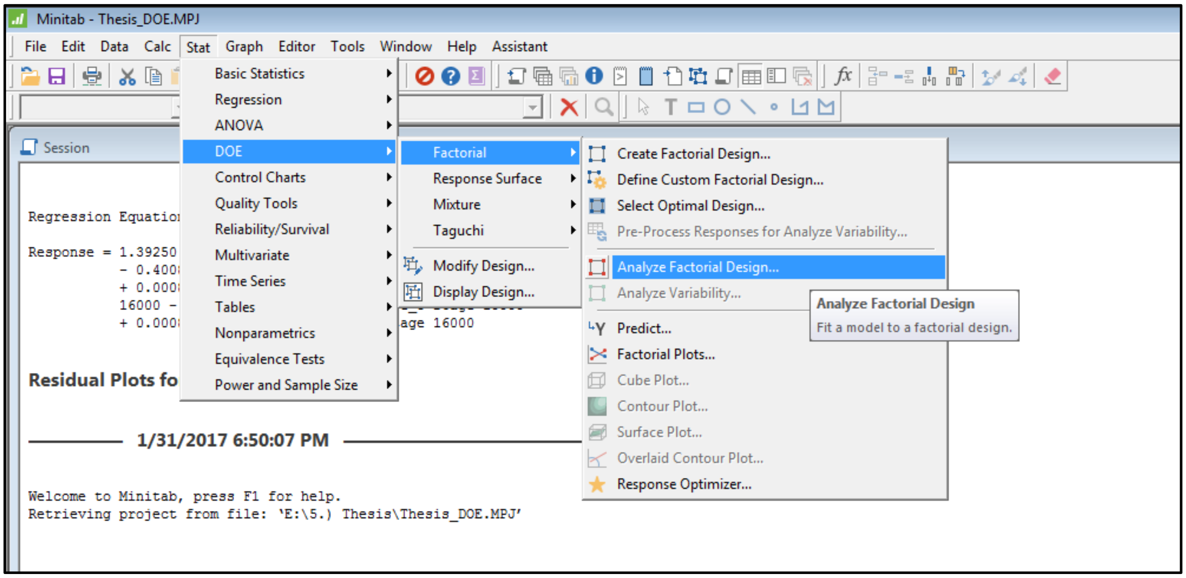

Figure 4.5: Steps to Analyze Factorial Design in Minitab®.

The last window that pops up asks for the response values. Simply select the response column previously created. Once all the settings have been verified, select the ok button. Minitab® then produces the results of the factorial design analysis, which includes a summary ANOVA table and regression equation. For the current study, any of the factors that were found to have a statistically significant difference between their low and high setting would then be analyzed at their medium and high setting. This follow-up DOE analysis would mimic the procedure used to analyze the low and high factor settings.

4.2 Results – Maximum Volumetric Airflow Output

For each of the initial DOE tests, an ANOVA summary table was generated. The ANOVA summary tables were comprised of values including: degrees of freedom (df), adjusted sum of squares (Adj SS), adjusted mean of squares (Adj MS), f-values (F), and p-values (P). Table 4.3 shows the values calculated for each of the initial DOE tests. An additional column indicates the factors and interactions found to have a statistically significant effect on the response variable of volumetric airflow output.

Table 4.3: Results - Maximum Volumetric Airflow Output Initial DOE's (Low and High Factor Settings).

Initial DOE Results						
10 mm Electrode Gap						
Source	df	Adj SS	Adj MS	F	P	
Material (Copper : Aluminum)	1	0.01333	0.01333	34.78	0.000	**Significant**
Voltage (7,500V : 10,000V)	1	1.1163	1.1163	2912.09	0.000	**Significant**
Interaction (Material : Voltage)	1	0.0012	0.0012	3.13	0.115	no significance
Shape (Cylindrical : Conical)	1	0.2523	0.2523	776.31	0.000	**Significant**
Voltage (11,000V : 13,000V)	1	0.77013	0.770133	2369.64	0.000	**Significant**
Interaction (Shape : Voltage)	1	0.00163	0.00163	5.03	0.055	no significance
Stages (4-Stage : 8-Stage)	1	0.00021	0.00021	0.5	0.5	no significance
Voltage (8,500V : 11,500V)	1	1.12241	1.12241	2693.78	0.000	**Significant**
Interaction (Stages : Voltage)	1	0.00067	0.00067	1.62	0.239	no significance
15 mm Electrode Gap						
Source	df	Adj SS	Adj MS	F	P	
Material (Copper : Aluminum)	1	0.01687	0.01687	69.83	0.000	**Significant**
Voltage (10,000V : 15,000V)	1	2.40307	2.40307	9943.76	0.000	**Significant**
Interaction (Material : Voltage)	1	0.00021	0.00021	0.86	0.38	no significance
Shape (Cylindrical : Conical)	1	0.4563	0.4563	1140.75	0.000	**Significant**
Voltage (15,000V : 18,000V)	1	0.70083	0.70083	1752.08	0.000	**Significant**
Interaction (Shape : Voltage)	1	0.05333	0.05333	133.33	0.000	**Significant**
Stages (4-Stage : 8-Stage)	1	0.00053	0.00053	1.45	0.262	no significance
Voltage (10,000V : 13,000V)	1	0.80083	0.80083	2184.09	0.000	**Significant**
Interaction (Stages : Voltage)	1	0.0003	0.0003	0.82	0.392	no significance
20 mm Electrode Gap						
Source	df	Adj SS	Adj MS	F	P	
Material (Copper : Aluminum)	1	0.16194	0.16194	726.17	0.000	**Significant**
Voltage (10,000V : 17,500V)	1	3.25104	3.25104	14578.7	0.000	**Significant**
Interaction (Material : Voltage)	1	0.0015	0.0015	6.71	0.032	**Significant**
Shape (Cylindrical : Conical)	1	1.2288	1.2288	3072	0.000	**Significant**
Voltage (17,500V : 20,750V)	1	0.57203	0.57203	1430.08	0.000	**Significant**
Interaction (Shape : Voltage)	1	0.02253	0.02253	56.33	0.000	**Significant**
Stages (4-Stage : 8-Stage)	1	0.00068	0.00068	2.31	0.167	no significance
Voltage (10,000V : 16,000V)	1	1.92801	1.92801	6610.31	0.000	**Significant**
Interaction (Stages : Voltage)	1	0.00001	0.00001	0.03	0.87	no significance

Following the initial DOE tests, a series of secondary DOE tests were performed on the medium and high settings of factors and interactions found to have a statistically significant effect on the response variable in the initial DOE tests. Another set of ANOVA summary tables were generated for the secondary DOE tests. Table 4.4 shows the results from the secondary DOE tests.

Table 4.4: Results - Maximum Volumetric Airflow Output Secondary DOE's (Medium and High Factor Settings).

Secondary DOE Results						
10 mm Electrode Gap						
Source	df	Adj SS	Adj MS	F	P	
Material (Conductive Graphite : Aluminum)	1	0.00185	0.00185	6.1	0.039	Significant
Voltage (7,500V : 10,000V)	1	1.23457	1.23457	4068.88	0.000	Significant
Interaction (Material : Voltage)	1	0.00796	0.00796	26.22	0.001	Significant
Shape (Parabolic : Conical)	1	0.00963	0.00963	26.88	0.001	Significant
Voltage (11,000V : 13,000V)	1	0.80083	0.80083	2234.88	0.000	Significant
Interaction (Shape : Voltage)	1	0.00333	0.00333	9.3	0.016	Significant
15 mm Electrode Gap						
Source	df	Adj SS	Adj MS	F	P	
Material (Conductive Graphite : Aluminum)	1	0.04813	0.04813	175.03	0.000	Significant
Voltage (10,000V : 15,000V)	1	2.7648	2.7648	10053.8	0.000	Significant
Interaction (Material : Voltage)	1	0.00963	0.00963	35.03	0.000	Significant
Shape (Parabolic : Conical)	1	0.04688	0.04688	112.5	0.000	Significant
Voltage (15,000V : 18,000V)	1	0.81641	0.81641	1959.38	0.000	Significant
Interaction (Shape : Voltage)	1	0.02708	0.02708	64.98	0.000	Significant
20 mm Electrode Gap						
Source	df	Adj SS	Adj MS	F	P	
Material (Conductive Graphite : Aluminum)	1	0.01643	0.01643	73.67	0.000	Significant
Voltage (10,000V : 17,500V)	1	3.6256	3.6256	16258.3	0.000	Significant
Interaction (Material : Voltage)	1	0.01952	0.01952	87.54	0.000	Significant
Shape (Parabolic : Conical)	1	0.24083	0.24083	760.53	0.000	Significant
Voltage (17,500V : 20,750V)	1	0.8427	0.8427	2661.16	0.000	Significant
Interaction (Shape : Voltage)	1	0.00013	0.00013	0.42	0.535	no significance

DOE results included coefficient values for each factor and interaction evaluated in the nine separate DOE's. Coefficients of factors and interactions that were found to be statistically significant were used to develop regression equations. Table 4.5 shows the regression equations formulated from the initial DOE tests.

Table 4.5: Regression Equations from Initial DOE Tests.

Material (-1 = Copper : 1 = Aluminum)	**Electrode Gap**	**Variables**
Y = 1.365 + 0.03333A + 0.305B	10 mm	A = Material (-1,1)
Y = 1.59083 + 0.0375A +0.4475B	15 mm	B = Voltage (-1,1)
Y = 1.44117 + 0.11617A + 0.5205B - 0.01117AB	20 mm	AB = Interaction (-1,1)
Shape (-1 = Cylindrical : 1 = Conical)	**Electrode Gap**	**Variables**
Y = 2.17667 + 0.145A + 0.25333B	10 mm	A = Shape (-1,1)
Y = 2.62333 + 0.195A + 0.24167B + 0.06667AB	15 mm	B = Voltage (-1,1)
Y = 2.55167 + 0.32A + 0.21833B + 0.04333AB	20 mm	AB = Interaction (-1,1)
Stages (-1 = Four-Stage : 1 = Eight-Stage)	**Electrode Gap**	**Variables**
Y = 1.6975 + 0.30583B	10 mm	B = Voltage (-1,1)
Y = 1.51 + 0.25833B	15mm	
Y = 1.3925 + 0.40083B	20 mm	

Regression equations could be used to estimate the response variable of volumetric airflow output. Values of -1 or 1 would be plugged into the equation for factors or interactions depending on whether the low or high setting is being used. The estimated value calculated from the regression equation could then be compared to the volumetric airflow output average of physically recorded values. The comparison of these two values was quantified with an error term. The error term was calculated by subtracting the estimated response variable from the average of the actual response variables. Table 4.6 shows the average of actual recorded volumetric airflow output values versus estimated values for each factor and interaction level at 10 mm. An error term for comparison is also included.

Table 4.6: Actual versus Estimated Response Variables for Material, Shape, and Stage Analysis at 10mm (Initial DOE).

10 mm		A (Material)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	1.0167	1.02667	-0.010003
	a	1	-1	1.1033	1.09333	0.010003
	b	-1	1	1.6467	1.63667	0.009997
	ab	1	1	1.6933	1.70333	-0.009997
		A (Shape)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	1.7667	1.77834	-0.011673
	a	1	-1	2.0800	2.06834	0.011660
	b	-1	1	2.2967	2.285	0.011667
	ab	1	1	2.5633	2.575	-0.011667
		A (Stages)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	1.3800	1.39167	-0.011670
	a	1	-1	1.4033	1.39167	0.011663
	b	-1	1	2.0067	2.00333	0.003337
	ab	1	1	2.0000	2.00333	-0.003330

Table 4.7 shows the average of actual recorded volumetric airflow output values versus estimated values for each factor and interaction level at 15 mm. An error term for comparison is also included in the table.

Table 4.7: Actual versus Estimated Response Variables for Material, Shape, and Stage Analysis at 15mm (Initial DOE).

15 mm		A (Material)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	1.1100	1.10583	0.004170
	a	1	-1	1.1767	1.18083	-0.004163
	b	-1	1	1.9967	2.00083	-0.004163
	ab	1	1	2.0800	2.07583	0.004170
		A (Shape)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	2.2533	2.25336	-0.0000267
	a	1	-1	2.5100	2.50999	0.0000100
	b	-1	1	2.6033	2.60333	0.0000033
	ab	1	1	3.1267	3.12667	-0.0000033
		A (Stages)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	1.2533	1.25167	0.001663
	a	1	-1	1.2500	1.25167	-0.001670
	b	-1	1	1.7800	1.76833	0.011670
	ab	1	1	1.7567	1.76833	-0.011663

Table 4.8 shows the average of actual recorded volumetric airflow output values versus estimated values for each factor and interaction level at 20 mm. An error term for comparison is also included. The error term indicates how accurately the regression equation estimates the volumetric airflow output value compared to the actual observed values.

Table 4.8: Actual versus Estimated Response Variables for Material, Shape, and Stage Analysis at 20mm (Initial DOE).

		A (Material)	B (Voltage)	Average	Predicted	Error
20 mm	[1]	-1	-1	0.7933	0.79333	0.0000033
	a	1	-1	1.0480	1.04801	-0.0000100
	b	-1	1	1.8567	1.85667	-0.0000033
	ab	1	1	2.0667	2.06667	-0.0000033
		A (Shape)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	2.0567	2.05667	-0.0000033
	a	1	-1	2.6100	2.61001	-0.0000100
	b	-1	1	2.4067	2.40667	-0.0000033
	ab	1	1	3.1333	3.13333	0.0000033
		A (Stages)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	1.0000	0.99167	0.008330
	a	1	-1	0.9833	0.99167	-0.008337
	b	-1	1	1.8000	1.79333	0.006670
	ab	1	1	1.7867	1.79333	-0.006663

An additional set of regression equations were formulated for the secondary DOE tests. Equations were produced for material and shape analysis results at 10mm, 15mm, and 20mm. For the material equations, conductive graphite was the low level (-1) and aluminum was the high level (1). For the shape equations, parabolic was the low level (-1) and conical was the high level (1). Table 4.9 shows the regression equations formulated from the secondary DOE tests. In the equations in Table 4.9, “A” represents the material level setting, “B” represents the voltage level setting, and “AB” represents the interaction level setting.

Table 4.9: Regression Equations from Secondary DOE Tests.

Material (-1 = Conductive Graphite : 1 = Aluminum)	**Electrode Gap**	**Variables**
Y = 1.38592 + 0.01242A + 0.32075B - 0.02575AB	10 mm	A = Material (-1,1)
Y = 1.69167 - 0.06333A + 0.48B - 0.02833AB	15 mm	B = Voltage (-1,1)
Y = 1.52033 + 0.037A + 0.54967B - 0.04033AB	20 mm	AB = Interaction (-1,1)
Shape (-1 = Parabolic : 1 = Conical)	**Electrode Gap**	**Variables**
Y = 2.29333 + 0.02833A +0.25833B - 0.01667AB	10 mm	A = Shape (-1,1)
Y = 2.75583 + 0.0625A + 0.26083B + 0.0475AB	15 mm	B = Voltage (-1,1)
Y = 2.73 + 0.14167A + 0.265B	20 mm	AB = Interaction (-1,1)

Similar to the previous process, regression equations were used to calculate estimated values of volumetric airflow output at the various factor and interaction level settings. Table 4.10 shows the average of actual recorded volumetric airflow output values versus estimated values for each factor and interaction level at 10 mm. An error term for comparison is also included. The error term indicates how accurately the regression equation estimates the volumetric airflow output value compared to the actual observed values.

Table 4.10: Actual versus Estimated Response Variables for Material, Shape, and Stage Analysis at 15mm (Secondary DOE).

		A (Material)	B (Voltage)	Average	Predicted	Error
10 mm	[1]	-1	-1	1.0270	1.027	0.000000
	a	1	-1	1.1033	1.10334	-0.000007
	b	-1	1	1.7200	1.72	0.000000
	ab	1	1	1.6933	1.69334	-0.000007
		A (Shape)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	1.9900	1.99	0.000000
	a	1	-1	2.0800	2.08	0.000000
	b	-1	1	2.5400	2.54	0.000000
	ab	1	1	2.5633	2.56332	0.000013

Table 4.11 shows the average of actual recorded volumetric airflow output values versus estimated values for each factor and interaction level at 15 mm. An error term for comparison is

also included. The error term indicates how accurately the regression equation estimates the volumetric airflow output value compared to the actual observed values.

Table 4.11: Actual versus Estimated Response Variables for Material, Shape, and Stage Analysis at 15mm (Secondary DOE).

		A (Material)	B (Voltage)	Average	Predicted	Error
15 mm	[1]	-1	-1	1.2467	1.24667	-0.000003
	a	1	-1	1.1767	1.17667	-0.000003
	b	-1	1	2.2633	2.26333	0.000003
	ab	1	1	2.0800	2.08001	-0.000010
		A (Shape)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	2.4800	2.48	0.000000
	a	1	-1	2.5100	2.51	0.000000
	b	-1	1	2.9067	2.90666	0.000007
	ab	1	1	3.1267	3.12666	0.000007

Table 4.12 shows the average of actual recorded volumetric airflow output values versus estimated values for each factor and interaction level at 20 mm. An error term for comparison is also included. The error term indicates how accurately the regression equation estimates the volumetric airflow output value compared to the actual observed values.

Table 4.12: Actual versus Estimated Response Variables for Material, Shape, and Stage Analysis at 15mm (Secondary DOE).

		A (Material)	B (Voltage)	Average	Predicted	Error
20 mm	[1]	-1	-1	0.8933	0.89333	0.0000033
	a	1	-1	1.0480	1.04799	0.0000100
	b	-1	1	2.0733	2.07333	0.0000033
	ab	1	1	2.0667	2.06667	-0.0000033
		A (Shape)	B (Voltage)	Average	Predicted	Error
	[1]	-1	-1	2.3200	2.32333	-0.003330
	a	1	-1	2.6100	2.60667	0.003330
	b	-1	1	2.8567	2.85333	0.003337
	ab	1	1	3.1333	3.13667	-0.003337

4.3 Results – Maximum Static Efficiency

For maximum static efficiency, a single value was determined for each data set. With no replication of each data set, a DOE or ANOVA analysis would produce inaccurate results due to the absence of variation. A Matlab® program was written to find the maximum value from the efficiency curve for each data set, which represented the maximum static efficiency value for each individual device. Table 4.13 shows the values of static efficiency for each individual device tested.

Table 4.13: Results - Maximum Static Efficiency.

Material Analysis			
10 mm	Aluminum	Conductive Graphite	Copper
7,500 V	0.28498%	0.28505%	0.38366%
8,750 V	0.25967%	0.27084%	0.34055%
10,000 V	0.20816%	0.24065%	0.27872%

Shape Analysis			
10 mm	Cylindrical	Conical	Parabolic
11,000 V	0.23173%	0.10291%	0.14622%
12,000 V	0.22980%	0.09535%	0.14029%
13,000 V	0.21610%	0.09419%	0.13564%

Multi-Stage Analysis			
10 mm	4-Stage	6-Stage	8-Stage
8,500 V	0.03667%	0.01657%	0.01475%
10,000 V	0.02365%	0.01746%	0.01470%
11,500 V	0.03451%	0.01811%	0.01192%

Material Analysis			
15 mm	Aluminum	Conductive Graphite	Copper
10,000 V	0.34376%	0.39275%	0.78340%
12,500 V	0.26367%	0.31566%	0.25437%
15,000 V	0.11187%	0.24934%	0.08448%

Shape Analysis			
15 mm	Cylindrical	Conical	Parabolic
15,000 V	0.24934%	0.10799%	0.13876%
16,750 V	0.21775%	0.09747%	0.11670%
18,000 V	0.11825%	0.09705%	0.10397%

Multi-Stage Analysis			
15 mm	4-Stage	6-Stage	8-Stage
10,000 V	0.02712%	0.01701%	0.01279%
11,500 V	0.02489%	0.01555%	0.01084%
13,000 V	0.02464%	0.01477%	0.01159%

Material Analysis			
20 mm	Aluminum	Conductive Graphite	Copper
10,000 V	6.79640%	1.41550%	3.62130%
15,000 V	0.26737%	0.33800%	0.21560%
17,500 V	0.11109%	0.23116%	0.09085%

Shape Analysis			
20 mm	Cylindrical	Conical	Parabolic
17,500 V	0.23116%	0.10357%	0.10866%
19,500 V	0.17548%	0.09332%	0.10666%
20,750 V	0.11687%	0.09101%	0.10127%

Multi-Stage Analysis			
20 mm	4-Stage	6-Stage	8-Stage
10,000 V	0.02726%	0.01656%	0.00986%
13,000 V	0.02078%	0.01437%	0.00898%
16,000 V	0.01564%	0.00993%	0.00792%

In order to compare the maximum static efficiency values, 3D plots were constructed for the material, shape and stage analysis. Each plot had axes which included the following: voltage level, electrode gap (distance between emitter and collector), and static efficiency value. Figure

4.6 shows the 3D efficiency plot for the material analysis. In Figure 4.6, efficiency values are illustrated at varying electric potential and electrode gap levels for each material. Materials tested included: aluminum, conductive graphite, and copper. The collector material efficiency analysis 3D plot was generated in Matlab®. Initial observations indicate that efficiency values are sensitive depending on the material and electrode gap combination selected. A general trend that efficiency decreases as voltage level increases can be seen.

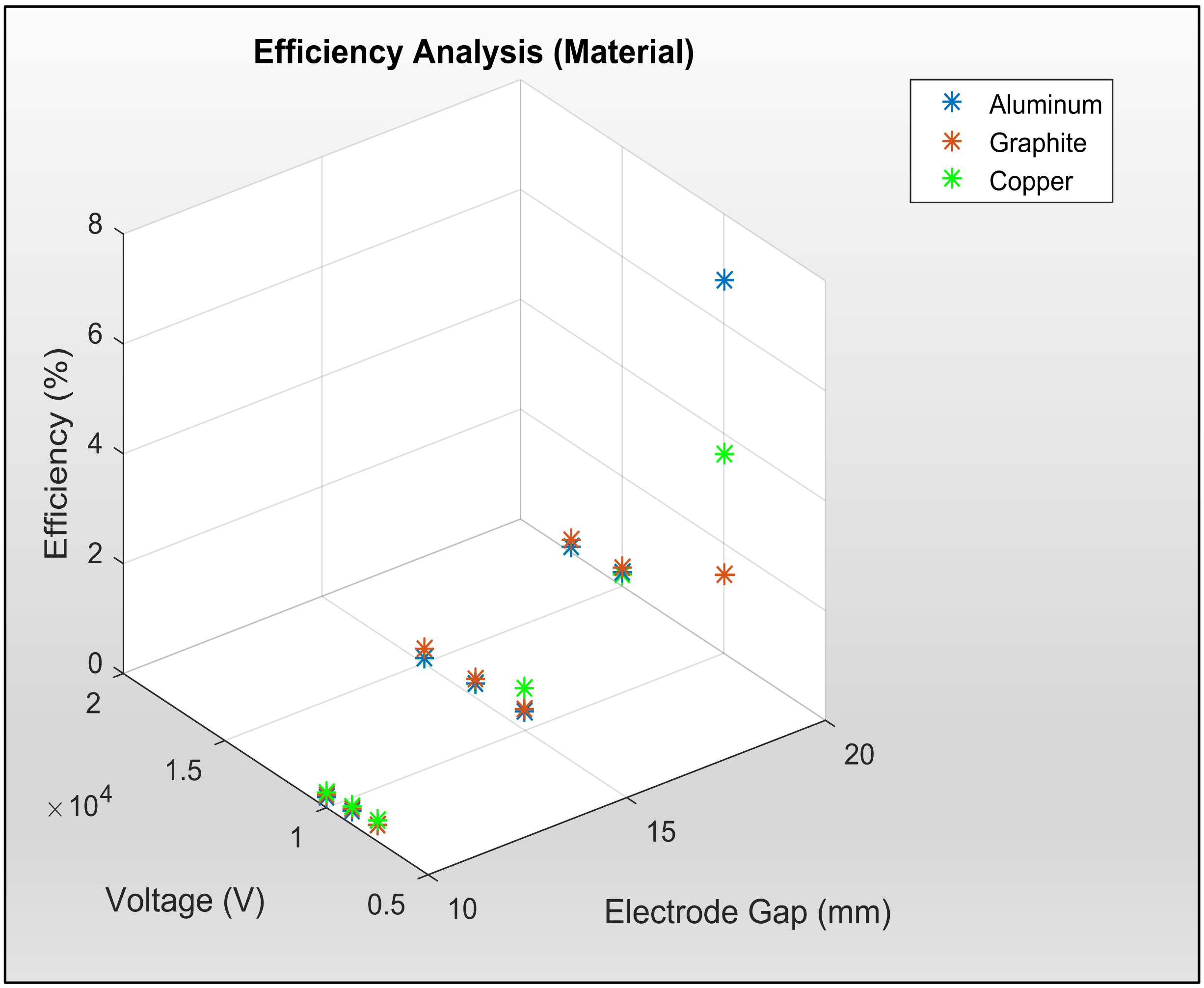

Figure 4.6: Results - 3D Efficiency Plot for Collector Material Analysis.

Figure 4.7 shows the 3D efficiency plot for the shape analysis. In Figure 4.7, efficiency values are illustrated at varying electric potential and electrode gap levels for each collector shape. Shapes tested included: cylindrical, conical, and parabolic. Initial observations show that cylindrical shaped collectors produce the highest values of efficiency at each tested electrode gap. It is also observed that conical shaped collectors yield the lowest values of static efficiency. A general trend that efficiency decreases as voltage level increases can be seen.

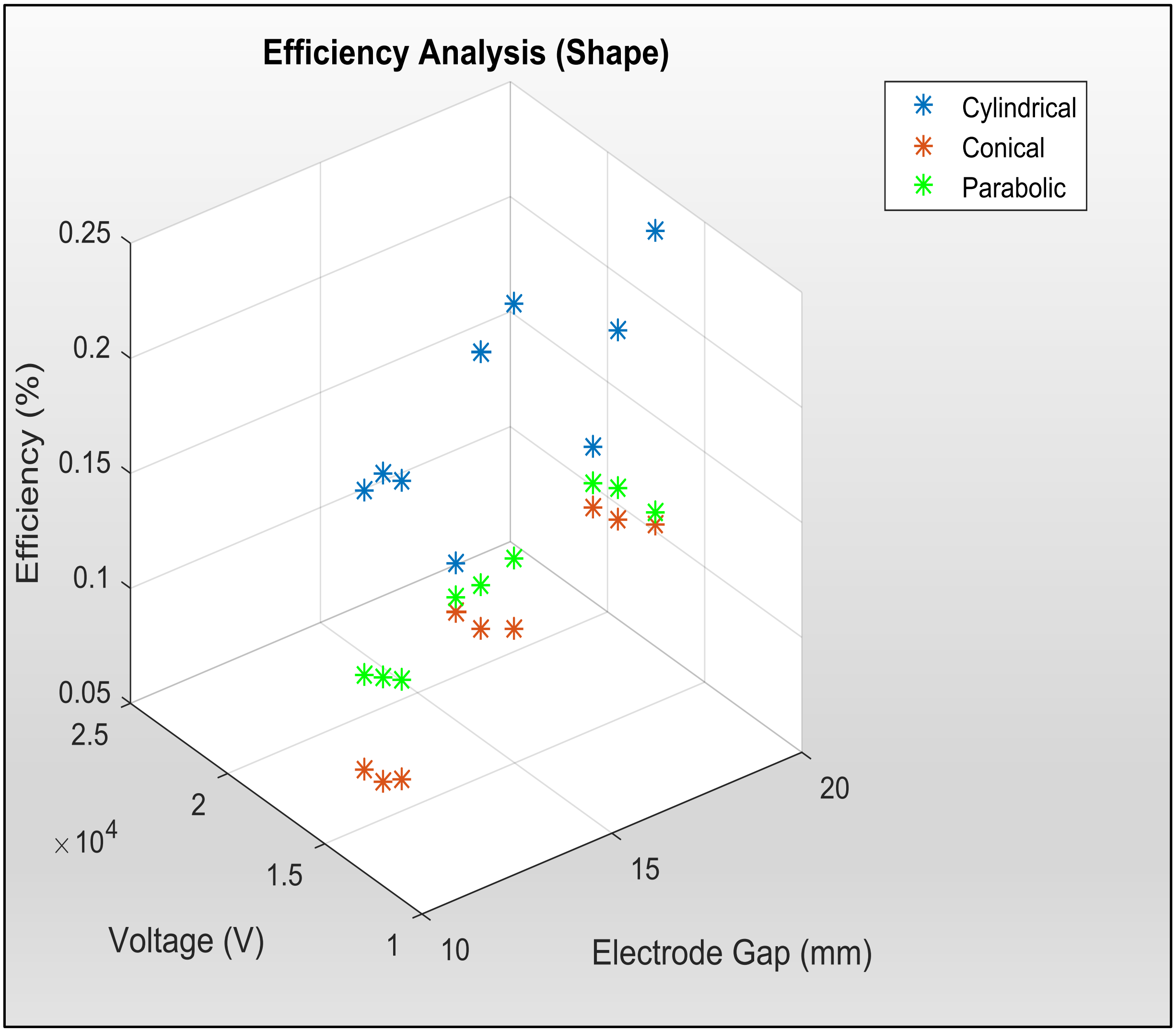

Figure 4.7: Results -3D Efficiency Plot for Collector Shape Analysis.

Figure 4.8 shows the 3D efficiency plot for the multi-stage analysis. In Figure 4.8, efficiency values are illustrated at varying electric potential and electrode gap levels for each collector stage level. Number of collector stages tested included: four-stage, six-stage, and eight stage. Initial observations indicate that the 4-stage collector configuration produces the highest values of static efficiency at each tested electrode gap. Additionally, the 8-stage collector configuration appears to yield the lowest values of efficiency. A general trend that efficiency decreases as voltage level increases can be seen.

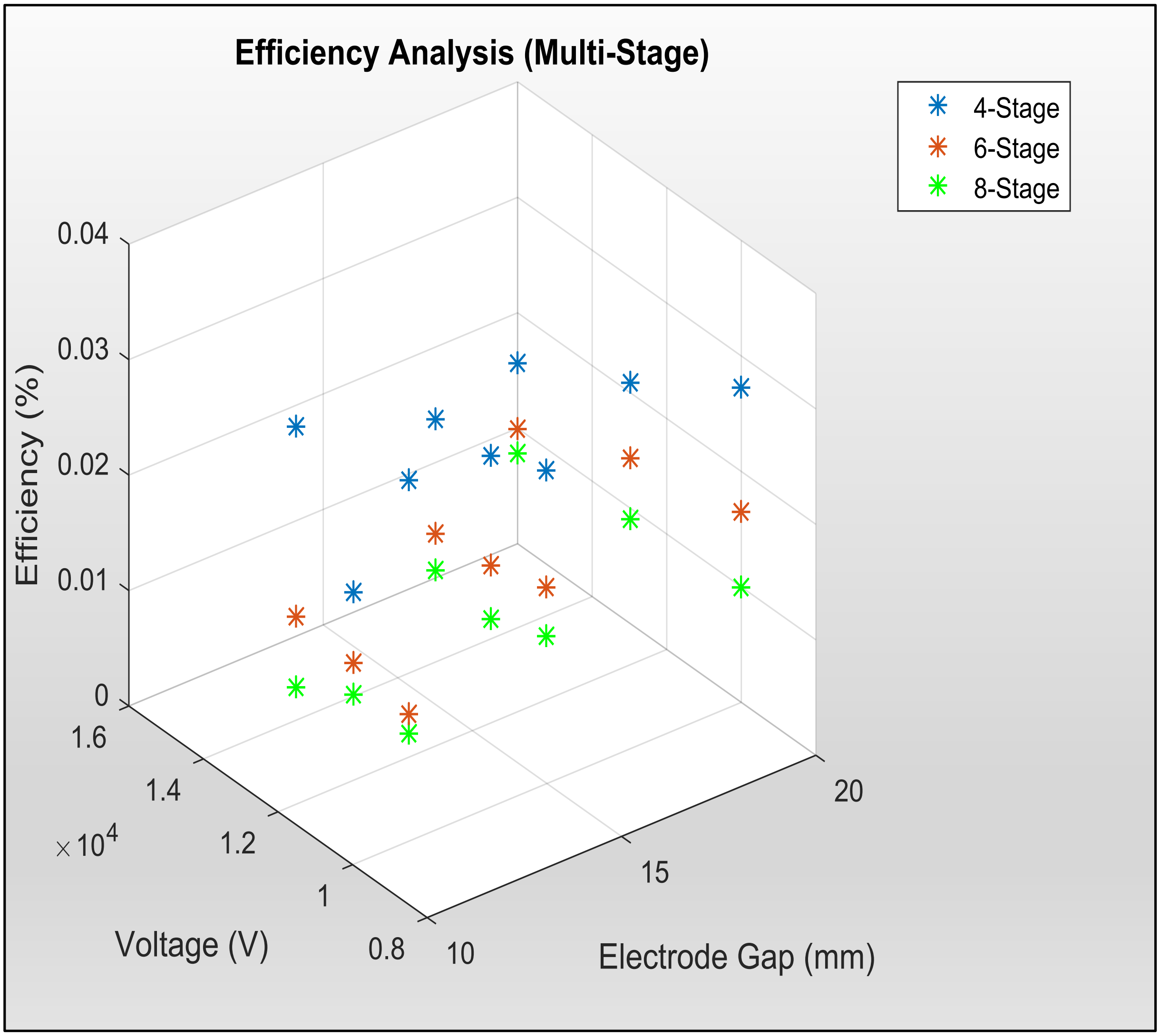

Figure 4.8: Results - 3D Efficiency Plot for Collector Stage Analysis.

CHAPTER 5: CONCLUSIONS AND FUTURE RESEARCH

This chapter analyzes the results obtained from the design of experiments to determine whether statistical significance can be attributed to the ionic air moving device parameter variation on volumetric airflow output. The analysis of the results from maximum static efficiency is also presented. Some discussion on the results and their correspondence with the literature is also provided. A brief overview of future research is also included in this chapter.

5.1 Conclusions

The increased volume of interest and research involving ionic air moving devices over the last couple of decades has generated a lot of excitement about the design, development and possibility of practical industrial implementation. Previous device designs and configurations have failed to produce the volumetric airflow output or static efficiency for use as a viable or reasonable stand-alone electronic cooling unit. Results from past studies have verified the plausibility of increasing ionic air moving device performance by varying the parameters and configurations of the device. However, further investigation into additional untested device parameters and configurations needs to be completed before ionic air moving devices can become a widespread industry standard in electronic cooling units. This study examined ionic air moving device parameters and configurations including collector material, collector shape, and number of collectors (stages). A series of design of experiments was conducted on collected data to determine whether the parameter variation caused a statistically significant fluctuation in maximum volumetric airflow output. Additionally, conclusions have been drawn about the effect of device parameter variation on static efficiency.

5.1.1 Analysis of Maximum Volumetric Airflow Output Results

The results from the design of experiments indicate that maximum volumetric airflow output of an ionic air moving device is statistically effected by the variation of certain device parameters and configurations. This conclusion is based on the results of a series of tests; which compared the maximum volumetric airflow output values produced by ionic air moving devices with differing parameters.

The material analysis shows that at every tested electrode gap, collector materials of aluminum, conductive graphite, and copper have a statistically significant effect on ionic air moving device, measured as the maximum volumetric airflow output. Results indicate that collector materials of aluminum and conductive graphite yield the highest airflow outputs. The general trend observed is that at lower voltages aluminum collectors produce the greatest airflow outputs. As supplied voltage increases, a point is reached where conductive graphite collectors begin performing better than aluminum collectors. Of the 3 electrode gaps tested (10, 15 and 20 mm), an electrode gap of 15 mm produced greater maximum volumetric airflow output for each collector material tested in this study. It is observed that at each electrode gap of the material analysis, the supplied levels of voltage have a statistically significant effect on the maximum volumetric airflow output of the ionic air moving device.

The shape analysis shows that at every tested electrode gap, collector shapes of cylindrical, conical, and parabolic have a statistically significant effect on the maximum volumetric airflow output of the ionic air moving device. Based on the experimental results, conically shaped collectors generate larger volumetric airflow outputs than collectors of cylindrical and parabolic shapes. This remains true throughout every electrode gap and voltage tested in this research. Additionally, it is seen that parabolic shaped collectors out performed cylindrical shaped collectors. It is seen that an electrode gap of 15 mm produces greater maximum volumetric airflow output for every collector shape than the other electrode gaps tested. It is observed that at each electrode gap of the shape analysis, the supplied levels of voltage have a statistically significant effect on the maximum volumetric airflow output of the ionic air moving device.

The multi-stage analysis shows that at every tested electrode gap, the number of collector stages of 4-stage, 6-stage, and 8-stage do not have a statistically significant effect on the maximum volumetric airflow output. It is seen that an electrode gap of 10 mm produces greater maximum volumetric airflow output for every collector stage level than the other electrode gaps tested in this study. It is observed that at each electrode gap of the multi-stage analysis, the supplied levels of voltage have a statistically significant effect on the maximum volumetric airflow output.

5.1.2 Analysis of Static Efficiency Results

The results from the static efficiency analysis indicate that maximum static efficiency of an ionic air moving device is effected by the variation of certain device parameters and configurations. This conclusion is based on the maximum static efficiency values produced by ionic air moving devices with differing parameters and configurations. A statistical determination cannot be declared for static efficiency results because replications of tests were not conducted in this study.

The material analysis shows that the maximum static efficiency values produced from collector materials of aluminum, conductive graphite, and copper fluctuate between electrode gaps. Results indicate that copper collectors yield the highest static efficiency at a 10 mm electrode gap. The general trend observed at a 15 and 20 mm electrode gap is that conductive graphite collectors produce the highest static efficiency at mid to higher voltage levels. It is observed that at each electrode gap of the material analysis, the supplied levels of voltage have a negative effect on static efficiency as voltage is increased.

The shape analysis shows that collector shapes of cylindrical, conical, and parabolic have differing effects on maximum static efficiency of ionic air moving devices. Results indicate that cylindrical shaped collectors yield the highest static efficiency at every tested electrode gap. It is seen that conical shaped collectors produce the lowest static efficiency. The general trend exhibited by the data is that smaller electrode gaps generate higher static efficiency values. It is observed that at each electrode gap of the shape analysis, the supplied levels of voltage have a negative effect on static efficiency as voltage is increased.

The multi-stage analysis shows that collector stages of 4-stage, 6-stage, and 8-stage have differing effects on maximum static efficiency of ionic air moving devices. Results indicate that 4-stage multi-stage collectors yield the highest static efficiency at every tested electrode gap. It is seen that 8-stage collectors produce the lowest static efficiency. The general trend exhibited by the data is that smaller electrode gaps generate higher static efficiency values. It is generally observed that at each electrode gap of the multi-stage analysis, the supplied levels of voltage have a negative effect on static efficiency as voltage is increased.

5.2 Future Scope

As benefits of ionic air moving devices begin to become increasingly more desired, and of greater interest, for industrial purposes, many aspects of device parameters and configurations need to be investigated further. Manipulation of ionic air moving device parameters and configurations have been proven to have a significant effect on volumetric airflow output and static efficiency [15, 21, 24, 25, 26, 27, 28, 33]. Although several studies have been conducted that are focused on parameters and configurations effecting ionic air moving device performance, further studies need to be conducted to identify additional methods of increasing device performance.

The current study had a limitation of individually analyzing collector material, collector shape, and number of collector stages. It would be useful to conduct future test, which investigated these parameters simultaneously. This would provide interaction properties, which could lead to further refinement of optimal device settings. A study investigating a single ionic air moving device constructed of the parameters found to be optimal in the current study would be very useful. The current study required different supplied voltage levels for each analysis in order to reach maximum volumetric airflow output. This was due to the occurrence of arcing at differing voltages for each material, shape, and number of stages.

In addition to investigations into effects of parameter interaction, research focused on optimal electrode gap for conical and parabolic shaped collectors would be beneficial. Previous research [26], has determined that the optimal electrode gap for a cylindrical shaped collector and needle type emitter is approximately 12mm. However, further investigation is necessary to determine what electrode gap produces the best results for different shaped collectors. Along the same topic, research into optimal electrode gap for materials other than aluminum should be conducted.

In the current study, results of the multi-stage analysis conflict with results of previous studies [24]. A suspected cause of these inconsistent results could be attributed to the open design of the holding apparatus. Future research investigating multi-stage collectors while utilizing a closed holding apparatus design would be useful for comparing results of previous research. Additionally, investigation into optimal electrode gap for multi-stage collectors would be beneficial. Based on the data of the current study, the optimum electrode gap appears to be at or below 10mm. However, this assumption cannot be made until further research is conducted to verify this observation.

In the current study, it was observed that conical and parabolic shaped collector's produces greater volumetric airflow outputs than cylindrical shaped collectors. Future research focused on the optimization of the dimensions of conical and parabolic shaped collectors would be very useful. For conical shaped collectors, it would be interesting to see what, if any, effect variation of the pitch angle has on device performance. Similarly, investigation into the effect of varying the radius size of a parabolic shaped collector would produce useful results.

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APPENDIX A

The following tables show the collected raw data of the tested ionic air moving devices.

Aluminum / Cylinder / 10mm / 7,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.12	0	7501	0.0000175	0.000528581	0	0
1.07	0.001	7501	0.0000174	0.000504983	0.24884	0.000962784
0.94	0.002	7500	0.0000176	0.00044363	0.49768	0.00167262
0.79	0.003	7500	0.0000175	0.000372838	0.74652	0.002120618
0.73	0.004	7500	0.0000174	0.000344521	0.99536	0.00262776
0.64	0.005	7500	0.0000174	0.000302046	1.2442	0.002879737
0.461	0.006	7500	0.0000173	0.000217568	1.49304	0.002503561
0.385	0.007	7500	0.0000172	0.0001817	1.74188	0.00245348
0.236	0.008	7500	0.0000173	0.000111379	1.99072	0.001708866
0	0.009	7500	0.0000174	0	2.23956	0

Aluminum / Cylinder / 10mm / 8,750V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.47	0	8751	0.0000329	0.000693762	0	0
1.39	0.001	8750	0.0000328	0.000656006	0.24884	0.000568783
1.27	0.002	8750	0.0000327	0.000599373	0.49768	0.001042537
1.18	0.003	8750	0.0000327	0.000556897	0.74652	0.001452984
1.09	0.004	8750	0.0000328	0.000514422	0.99536	0.001784095
1.025	0.005	8749	0.0000327	0.000483746	1.2442	0.002103784
0.91	0.006	8749	0.0000326	0.000429472	1.49304	0.002248175
0.837	0.007	8749	0.0000327	0.00039502	1.74188	0.002405087
0.77	0.008	8749	0.0000328	0.000363399	1.99072	0.002520936
0.68	0.009	8749	0.0000328	0.000320924	2.23956	0.002504567
0.56	0.01	8749	0.0000328	0.00026429	2.4884	0.00229176
0.454	0.011	8749	0.0000329	0.000214264	2.73724	0.002037547
0.183	0.012	8749	0.0000328	8.63663E-05	2.98608	0.000898697
0	0.013	8749	0.0000328	0	3.23492	0

Aluminum / Cylinder / 10mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.71	0	10002	0.0000575	0.000807029	0	0
1.68	0.001	10002	0.0000573	0.000792871	0.24884	0.000344256
1.62	0.002	10002	0.0000569	0.000764554	0.49768	0.000668589
1.54	0.003	10001	0.0000566	0.000726798	0.74652	0.000958508
1.49	0.004	10001	0.0000568	0.000703201	0.99536	0.001232162
1.4	0.005	10001	0.0000568	0.000660726	1.2442	0.00144717
1.34	0.006	10001	0.0000566	0.000632409	1.49304	0.001668052
1.26	0.007	10001	0.0000563	0.000594653	1.74188	0.001839629
1.17	0.008	10001	0.0000565	0.000552178	1.99072	0.001945348
1.09	0.009	10001	0.0000565	0.000514422	2.23956	0.002038875
0.95	0.01	10001	0.000056	0.00044835	2.4884	0.001992074
0.88	0.011	10001	0.0000562	0.000415313	2.73724	0.002022596
0.79	0.012	10001	0.0000562	0.000372838	2.98608	0.001980806
0.7	0.013	10001	0.0000561	0.000330363	3.23492	0.001904796
0.56	0.014	10001	0.0000562	0.00026429	3.48376	0.001638135
0.45	0.015	10001	0.0000564	0.000212376	3.7326	0.001405383
0.36	0.016	10001	0.0000563	0.000169901	3.98144	0.00120139
0.2	0.017	10001	0.0000562	9.43894E-05	4.23028	0.000710416
0	0.018	10001	0.0000561	0	4.47912	0

Aluminum / Cylinder / 15mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.19	0	10001	0.000013	0.000561617	0	0
1.12	0.001	10001	0.0000127	0.000528581	0.24884	0.001035582
1.05	0.002	10001	0.0000126	0.000495544	0.49768	0.001957126
0.89	0.003	10001	0.0000126	0.000420033	0.74652	0.002488346
0.817	0.004	10001	0.0000127	0.000385581	0.99536	0.003021679
0.716	0.005	10001	0.0000126	0.000337914	1.2442	0.003336434
0.59	0.006	10001	0.0000126	0.000278449	1.49304	0.003299155
0.44	0.007	10001	0.0000126	0.000207657	1.74188	0.002870451
0.32	0.008	10001	0.0000126	0.000151023	1.99072	0.00238583
0	0.009	10001	0.0000126	0	2.23956	0

Aluminum / Cylinder / 15mm / 12,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.88	0	12500	0.0000441	0.00088726	0	0
1.81	0.001	12500	0.0000438	0.000854224	0.24884	0.000388247
1.76	0.002	12500	0.0000433	0.000830627	0.49768	0.000763762
1.704	0.003	12500	0.0000435	0.000804198	0.74652	0.001104091
1.67	0.004	12500	0.0000431	0.000788151	0.99536	0.001456138
1.566	0.005	12500	0.0000427	0.000739069	1.2442	0.00172281
1.514	0.006	12500	0.0000425	0.000714528	1.49304	0.002008129
1.42	0.007	12500	0.0000419	0.000670165	1.74188	0.002228824
1.36	0.008	12500	0.0000415	0.000641848	1.99072	0.002463112
1.244	0.009	12500	0.0000413	0.000587102	2.23956	0.002546926
1.18	0.01	12500	0.0000414	0.000556897	2.4884	0.002677843
1.04	0.011	12500	0.0000413	0.000490825	2.73724	0.002602432
0.94	0.012	12500	0.0000411	0.00044363	2.98608	0.002578521
0.83	0.013	12500	0.000041	0.000391716	3.23492	0.002472527
0.67	0.014	12500	0.0000411	0.000316204	3.48376	0.002144196
0.579	0.015	12500	0.0000411	0.000273257	3.7326	0.001985324
0.488	0.016	12500	0.0000408	0.00023031	3.98144	0.001797973
0.29	0.017	12500	0.0000414	0.000136865	4.23028	0.001118794
0.123	0.018	12500	0.0000405	5.80495E-05	4.47912	0.000513601
0	0.019	12500	0.0000407	0	4.72796	0

Aluminum / Cylinder / 15mm / 15,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.09	0	15001	0.000285	0.000986369	0	0
2.03	0.002	15000	0.000256	0.000958052	0.49768	0.000124168
1.98	0.003	15000	0.000255	0.000934455	0.74652	0.000182376
1.904	0.004	15000	0.000252	0.000898587	0.99536	0.000236618
1.86	0.005	15000	0.000265	0.000877821	1.2442	0.000274764
1.78	0.006	15000	0.00022	0.000840066	1.49304	0.000380076
1.75	0.007	15000	0.000215	0.000825907	1.74188	0.000446087
1.72	0.008	15000	0.000202	0.000811749	1.99072	0.000533322
1.69	0.009	14999	0.000197	0.00079759	2.23956	0.000604525
1.62	0.01	15000	0.000187	0.000764554	2.4884	0.000678259
1.56	0.011	14999	0.000187	0.000736237	2.73724	0.0007185

1.52	0.012	14999	0.000186	0.000717359	2.98608	0.000767826
1.305	0.013	15001	0.000113	0.000615891	3.23492	0.001175354
1.252	0.014	15002	0.000112	0.000590878	3.48376	0.00122512
1.18	0.015	15000	0.000113	0.000556897	3.7326	0.001226357
1.05	0.016	15001	0.000117	0.000495544	3.98144	0.00112413
0.97	0.017	15001	0.000116	0.000457789	4.23028	0.001112899
0.915	0.018	15001	0.000116	0.000431832	4.47912	0.00111155
0.79	0.019	15001	0.000117	0.000372838	4.72796	0.001004357
0.74	0.02	15001	0.000117	0.000349241	4.9768	0.000990305
0.47	0.021	15001	0.000119	0.000221815	5.22564	0.000649327
0.406	0.022	15000	0.000117	0.00019161	5.47448	0.000597702
0.26	0.023	15000	0.000118	0.000122706	5.72332	0.000396772
0.128	0.024	15000	0.000117	6.04092E-05	5.97216	0.000205569
0	0.025	15001	0.000115	0	6.221	0

Aluminum / Cylinder / 20mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.064	0	10000	4.29E-07	0.00050215	0	0
0.99	0.001	10000	4.27E-07	0.00046723	0.24884	0.0272283
0.86	0.002	10000	4.26E-07	0.00040587	0.49768	0.0474168
0.72	0.003	10000	4.27E-07	0.0003398	0.74652	0.0594072
0.64	0.004	10000	4.27E-07	0.00030205	0.99536	0.0704086
0.458	0.005	10000	4.27E-07	0.00021615	1.2442	0.0629827
0.22	0.006	10000	4.29E-07	0.00010383	1.49304	0.0361352
0	0.007	10000	4.3E-07	0	1.74188	0

Aluminum / Cylinder / 20mm / 15,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.82	0	15002	3.63E-05	0.00085894	0	0
1.77	0.001	15002	3.54E-05	0.00083535	0.24884	0.0003914
1.71	0.002	15002	3.42E-05	0.00080703	0.49768	0.0007828
1.67	0.003	15002	3.29E-05	0.00078815	0.74652	0.0011921
1.608	0.004	15002	3.22E-05	0.00075889	0.99536	0.0015637
1.51	0.005	15002	3.18E-05	0.00071264	1.2442	0.0018586
1.45	0.006	15002	3.24E-05	0.00068432	1.49304	0.002102

1.343	0.007	15002	3.15E-05	0.00063382	1.74188	0.0023363
1.26	0.008	15002	3.12E-05	0.00059465	1.99072	0.0025291
1.19	0.009	15002	3.14E-05	0.00056162	2.23956	0.0026701
1.064	0.01	15002	3.13E-05	0.00050215	2.4884	0.0026611
0.913	0.011	15002	3.11E-05	0.00043089	2.73724	0.0025279
0.84	0.012	15002	3.11E-05	0.00039644	2.98608	0.0025373
0.721	0.013	15002	0.000031	0.00034027	3.23492	0.0023669
0.49	0.014	15001	3.14E-05	0.00023125	3.48376	0.0017104
0.352	0.015	15001	3.12E-05	0.00016613	3.7326	0.0013249
0.125	0.016	15001	3.13E-05	5.8993E-05	3.98144	0.0005002
0	0.017	15001	3.12E-05	0	4.23028	0

Aluminum / Cylinder / 20mm / 17,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.08	0	17500	0.000119	0.00098165	0	0
1.99	0.002	17500	0.000118	0.00093917	0.49768	0.0002263
1.905	0.003	17500	0.000113	0.00089906	0.74652	0.0003394
1.89	0.004	17500	0.000112	0.00089198	0.99536	0.000453
1.84	0.005	17500	0.000108	0.00086838	1.2442	0.0005717
1.81	0.006	17500	0.000107	0.00085422	1.49304	0.0006811
1.742	0.007	17500	0.000105	0.00082213	1.74188	0.0007793
1.657	0.008	17500	0.000103	0.00078202	1.99072	0.0008637
1.592	0.009	17500	0.000101	0.00075134	2.23956	0.000952
1.56	0.01	17500	0.000101	0.00073624	2.4884	0.0010365
1.45	0.011	17500	0.000098	0.00068432	2.73724	0.0010922
1.37	0.012	17500	0.000102	0.00064657	2.98608	0.0010816
1.28	0.013	17500	0.000102	0.00060409	3.23492	0.0010948
1.17	0.014	17500	0.000104	0.00055218	3.48376	0.001057
1.09	0.015	17500	0.000107	0.00051442	3.7326	0.0010254
1.01	0.016	17500	0.000106	0.00047667	3.98144	0.0010231
0.88	0.017	17500	0.000106	0.00041531	4.23028	0.0009471
0.814	0.018	17500	0.000105	0.00038416	4.47912	0.0009364
0.749	0.019	17500	0.000106	0.00035349	4.72796	0.000901
0.518	0.02	17500	0.000112	0.00024447	4.9768	0.0006208
0.389	0.021	17500	0.000113	0.00018359	5.22564	0.0004851
0.122	0.022	17500	0.000112	5.7578E-05	5.47448	0.0001608
0	0.023	17500	0.000114	0	5.72332	0

Conductive Graphite / Cylinder / 10mm / 7,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.041	0	7500	0.0000174	0.0004913	0	0
0.98	0.001	7500	0.0000174	0.00046251	0.24884	0.0008819
0.89	0.002	7500	0.0000173	0.00042003	0.49768	0.0016111
0.826	0.003	7499	0.0000171	0.00038983	0.74652	0.0022694
0.72	0.004	7500	0.0000174	0.0003398	0.99536	0.0025918
0.64	0.005	7500	0.0000172	0.00030205	1.2442	0.0029132
0.49	0.006	7500	0.0000168	0.00023125	1.49304	0.0027403
0.401	0.007	7500	0.0000169	0.00018925	1.74188	0.0026008
0.248	0.008	7500	0.0000157	0.00011704	1.99072	0.0019788
0.176	0.009	7500	0.0000162	8.3063E-05	2.23956	0.0015311
0	0.01	7500	0.0000161	0	2.4884	0

Conductive Graphite / Cylinder / 10mm / 8,750V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.43	0	8750	0.0000338	0.00067488	0	0
1.39	0.001	8750	0.0000341	0.00065601	0.24884	0.0005471
1.31	0.002	8750	0.0000334	0.00061825	0.49768	0.0010528
1.24	0.003	8750	0.0000334	0.00058521	0.74652	0.0014949
1.17	0.004	8750	0.0000342	0.00055218	0.99536	0.0018366
1.13	0.005	8750	0.0000341	0.0005333	1.2442	0.0022238
1.03	0.006	8750	0.000034	0.00048611	1.49304	0.0024396
0.91	0.007	8750	0.0000339	0.00042947	1.74188	0.002522
0.85	0.008	8750	0.0000335	0.00040115	1.99072	0.0027244
0.76	0.009	8750	0.0000342	0.00035868	2.23956	0.0026843
0.64	0.01	8750	0.0000334	0.00030205	2.4884	0.0025718
0.52	0.011	8750	0.0000333	0.00024541	2.73724	0.0023055
0.44	0.012	8750	0.0000335	0.00020766	2.98608	0.0021154
0.28	0.013	8750	0.0000337	0.00013215	3.23492	0.0014497
0.15	0.014	8750	0.0000342	7.0792E-05	3.48376	0.0008241
0	0.015	8750	0.0000339	0	3.7326	0

Conductive Graphite / Cylinder / 10mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.73	0	10001	0.0000545	0.00081647	0	0
1.67	0.001	10001	0.0000545	0.00078815	0.24884	0.0003598
1.62	0.002	10001	0.0000542	0.00076455	0.49768	0.000702
1.57	0.003	10001	0.0000542	0.00074096	0.74652	0.0010204
1.51	0.004	10001	0.0000542	0.00071264	0.99536	0.0013086
1.46	0.005	10000	0.0000539	0.00068904	1.2442	0.0015906
1.37	0.006	10000	0.0000539	0.00064657	1.49304	0.001791
1.32	0.007	10000	0.0000538	0.00062297	1.74188	0.002017
1.24	0.008	10000	0.0000537	0.00058521	1.99072	0.0021695
1.16	0.009	10000	0.0000541	0.00054746	2.23956	0.0022663
1.11	0.01	10000	0.0000538	0.00052386	2.4884	0.002423
0.99	0.011	10000	0.000054	0.00046723	2.73724	0.0023684
0.91	0.012	10000	0.0000538	0.00042947	2.98608	0.0023837
0.8	0.013	10000	0.0000536	0.00037756	3.23492	0.0022787
0.74	0.014	10000	0.0000538	0.00034924	3.48376	0.0022615
0.61	0.015	10000	0.0000539	0.00028789	3.7326	0.0019936
0.56	0.016	10000	0.0000541	0.00026429	3.98144	0.001945
0.49	0.017	10000	0.000054	0.00023125	4.23028	0.0018116
0.42	0.018	10000	0.000054	0.00019822	4.47912	0.0016442
0.29	0.019	10000	0.0000539	0.00013686	4.72796	0.0012005
0.25	0.02	10000	0.000054	0.00011799	4.9768	0.0010874
0	0.021	10000	0.0000541	0	5.22564	0

Conductive Graphite / Cylinder / 15mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.27	0	10000	0.0000149	0.00059937	0	0
1.24	0.001	10000	0.0000147	0.00058521	0.24884	0.0009906
1.18	0.002	10000	0.0000148	0.0005569	0.49768	0.0018727
1.1	0.003	10000	0.0000145	0.00051914	0.74652	0.0026728
1.02	0.004	10000	0.0000144	0.00048139	0.99536	0.0033274
0.92	0.005	10000	0.0000143	0.00043419	1.2442	0.0037778
0.79	0.006	10000	0.0000143	0.00037284	1.49304	0.0038927
0.68	0.007	10000	0.000014	0.00032092	1.74188	0.0039929
0.56	0.008	10000	0.0000141	0.00026429	1.99072	0.0037314

0.41	0.009	10000	0.0000142	0.0001935	2.23956	0.0030518
0.28	0.01	10000	0.000014	0.00013215	2.4884	0.0023488
0.145	0.011	10000	0.000014	6.8432E-05	2.73724	0.001338
0	0.012	10000	0.000014	0	2.98608	0

Conductive Graphite / Cylinder / 15mm / 12,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.81	0	12500	0.000037	0.00085422	0	0
1.74	0.001	12500	0.000037	0.00082119	0.24884	0.0004418
1.69	0.002	12500	0.0000363	0.00079759	0.49768	0.0008748
1.65	0.003	12500	0.0000365	0.00077871	0.74652	0.0012741
1.59	0.004	12500	0.0000364	0.0007504	0.99536	0.0016416
1.52	0.005	12500	0.0000362	0.00071736	1.2442	0.0019725
1.46	0.006	12500	0.0000363	0.00068904	1.49304	0.0022673
1.39	0.007	12500	0.000036	0.00065601	1.74188	0.0025393
1.33	0.008	12500	0.000036	0.00062769	1.99072	0.0027768
1.26	0.009	12500	0.000036	0.00059465	2.23956	0.0029595
1.18	0.01	12500	0.0000358	0.0005569	2.4884	0.0030967
1.06	0.011	12500	0.000036	0.00050026	2.73724	0.003043
0.97	0.012	12500	0.0000361	0.00045779	2.98608	0.0030293
0.91	0.013	12500	0.000036	0.00042947	3.23492	0.0030873
0.79	0.014	12500	0.000036	0.00037284	3.48376	0.0028864
0.72	0.015	12500	0.0000359	0.0003398	3.7326	0.0028264
0.58	0.016	12501	0.0000363	0.00027373	3.98144	0.0024017
0.46	0.017	12500	0.0000359	0.0002171	4.23028	0.0020465
0.34	0.018	12500	0.0000358	0.00016046	4.47912	0.0016061
0.16	0.019	12500	0.0000358	7.5512E-05	4.72796	0.0007978
0	0.02	12500	0.0000358	0	4.9768	0

Conductive Graphite / Cylinder / 15mm / 15,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.27	0	15000	0.000082	0.00107132	0	0
2.21	0.002	15000	0.0000768	0.001043	0.49768	0.0004506
2.16	0.003	15000	0.0000751	0.00101941	0.74652	0.0006755
2.12	0.004	15000	0.0000748	0.00100053	0.99536	0.0008876

2.08	0.005	15000	0.0000736	0.00098165	1.2442	0.0011063
2.01	0.006	15000	0.000074	0.00094861	1.49304	0.001276
1.96	0.007	15000	0.0000741	0.00092502	1.74188	0.0014496
1.92	0.008	15000	0.0000734	0.00090614	1.99072	0.0016384
1.89	0.009	15000	0.0000737	0.00089198	2.23956	0.001807
1.81	0.01	15000	0.0000736	0.00085422	2.4884	0.0019254
1.77	0.011	15000	0.0000728	0.00083535	2.73724	0.0020939
1.72	0.012	15000	0.0000737	0.00081175	2.98608	0.0021926
1.68	0.013	15000	0.000073	0.00079287	3.23492	0.0023424
1.57	0.014	15000	0.0000733	0.00074096	3.48376	0.0023477
1.51	0.015	15000	0.0000734	0.00071264	3.7326	0.002416
1.46	0.016	15000	0.0000731	0.00068904	3.98144	0.0025019
1.37	0.017	15000	0.0000729	0.00064657	4.23028	0.0025013
1.26	0.018	15000	0.0000726	0.00059465	4.47912	0.0024458
1.21	0.019	15000	0.0000723	0.00057106	4.72796	0.0024896
1.09	0.02	15000	0.0000735	0.00051442	4.9768	0.0023222
0.98	0.021	15000	0.0000733	0.00046251	5.22564	0.0021982
0.93	0.022	15000	0.0000731	0.00043891	5.47448	0.0021913
0.84	0.023	15000	0.000073	0.00039644	5.72332	0.0020721
0.71	0.024	15000	0.0000727	0.00033508	5.97216	0.0018351
0.63	0.025	15000	0.000073	0.00029733	6.221	0.0016892
0.55	0.026	15000	0.0000732	0.00025957	6.46984	0.0015295
0.48	0.027	15000	0.0000733	0.00022653	6.71868	0.0013843
0.31	0.028	15000	0.0000733	0.0001463	6.96752	0.0009271
0.12	0.029	15000	0.000073	5.6634E-05	7.21636	0.0003732
0	0.03	15000	0.0000729	0	7.4652	0

Conductive Graphite / Cylinder / 20mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
0.91	0	10000	1.73E-06	0.00042947	0	0
0.77	0.001	10000	1.57E-06	0.0003634	0.24884	0.0057598
0.71	0.002	10000	1.43E-06	0.00033508	0.49768	0.0116618
0.63	0.003	10000	1.44E-06	0.00029733	0.74652	0.0154139
0.44	0.004	10000	1.39E-06	0.00020766	0.99536	0.01487
0.27	0.005	10000	1.53E-06	0.00012743	1.2442	0.0103623
0.13	0.006	10000	1.51E-06	6.1353E-05	1.49304	0.0060664
0	0.007	10000	0.0000015	0	1.74188	0

Conductive Graphite / Cylinder / 20mm / 15,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.74	0	15000	0.0000251	0.00082119	0	0
1.66	0.001	15000	0.000025	0.00078343	0.24884	0.0005199
1.61	0.002	15000	0.0000242	0.00075983	0.49768	0.0010417
1.57	0.003	15000	0.0000242	0.00074096	0.74652	0.0015238
1.49	0.004	15000	0.000024	0.0007032	0.99536	0.0019443
1.42	0.005	15000	0.000024	0.00067016	1.2442	0.0023162
1.38	0.006	15000	0.0000239	0.00065129	1.49304	0.0027124
1.25	0.007	15000	0.0000233	0.00058993	1.74188	0.0029402
1.18	0.008	15000	0.0000232	0.0005569	1.99072	0.0031857
1.09	0.009	15000	0.0000229	0.00051442	2.23956	0.0033539
1.01	0.01	15000	0.0000232	0.00047667	2.4884	0.0034084
0.85	0.011	15000	0.000023	0.00040115	2.73724	0.0031828
0.76	0.012	15000	0.0000224	0.00035868	2.98608	0.0031876
0.59	0.013	15000	0.0000219	0.00027845	3.23492	0.002742
0.51	0.014	15000	0.0000217	0.00024069	3.48376	0.0025761
0.302	0.015	15000	0.0000217	0.00014253	3.7326	0.0016344
0.16	0.016	15000	0.0000217	7.5512E-05	3.98144	0.0009236
0	0.017	15000	0.0000217	0	4.23028	0

Conductive Graphite / Cylinder / 20mm / 17,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.08	0	17500	0.00005	0.00098165	0	0
2.01	0.002	17500	0.0000482	0.00094861	0.49768	0.0005597
1.97	0.003	17500	0.0000478	0.00092974	0.74652	0.0008297
1.89	0.004	17500	0.0000485	0.00089198	0.99536	0.0010461
1.83	0.005	17500	0.0000484	0.00086366	1.2442	0.0012687
1.79	0.006	17500	0.0000484	0.00084479	1.49304	0.0014891
1.74	0.007	17500	0.0000485	0.00082119	1.74188	0.0016853
1.69	0.008	17500	0.0000479	0.00079759	1.99072	0.0018942
1.62	0.009	17500	0.0000486	0.00076455	2.23956	0.0020132
1.55	0.01	17500	0.0000493	0.00073152	2.4884	0.0021099
1.46	0.011	17500	0.0000489	0.00068904	2.73724	0.002204
1.38	0.012	17500	0.0000491	0.00065129	2.98608	0.0022634
1.304	0.013	17500	0.0000494	0.00061542	3.23492	0.0023029

1.22	0.014	17500	0.0000493	0.00057578	3.48376	0.002325
1.16	0.015	17500	0.0000504	0.00054746	3.7326	0.0023168
0.98	0.016	17500	0.0000502	0.00046251	3.98144	0.0020961
0.87	0.017	17500	0.0000499	0.00041059	4.23028	0.001989
0.73	0.018	17500	0.0000496	0.00034452	4.47912	0.0017778
0.61	0.019	17500	0.0000497	0.00028789	4.72796	0.001565
0.54	0.02	17500	0.0000502	0.00025485	4.9768	0.0014438
0.43	0.021	17500	0.0000489	0.00020294	5.22564	0.0012392
0.23	0.022	17500	0.0000491	0.00010855	5.47448	0.0006916
0	0.023	17500	0.0000492	0	5.72332	0

Copper / Cylinder / 10mm / 7,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.04	0	7500	9.27E-06	0.00049082	0	0
0.92	0.001	7500	9.23E-06	0.00043419	0.24884	0.0015608
0.8	0.002	7500	9.19E-06	0.00037756	0.49768	0.0027262
0.71	0.003	7500	9.14E-06	0.00033508	0.74652	0.0036491
0.56	0.004	7500	9.06E-06	0.00026429	0.99536	0.0038714
0.42	0.005	7500	9.22E-06	0.00019822	1.2442	0.0035665
0.29	0.006	7500	9.01E-06	0.00013686	1.49304	0.003024
0.13	0.007	7500	9.03E-06	6.1353E-05	1.74188	0.001578
0	0.008	7500	9.04E-06	0	1.99072	0

Copper / Cylinder / 10mm / 8,750V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.35	0	8750	0.0000204	0.00063713	0	0
1.29	0.001	8750	0.0000203	0.00060881	0.24884	0.0008529
1.2	0.002	8750	0.0000203	0.00056634	0.49768	0.0015868
1.14	0.003	8750	0.0000202	0.00053802	0.74652	0.0022724
1.05	0.004	8750	0.0000201	0.00049554	0.99536	0.0028045
0.96	0.005	8750	0.0000201	0.00045307	1.2442	0.0032052
0.82	0.006	8750	0.0000201	0.000387	1.49304	0.0032853
0.71	0.007	8750	0.0000201	0.00033508	1.74188	0.0033187
0.62	0.008	8750	0.00002	0.00029261	1.99072	0.0033286
0.48	0.009	8750	0.00002	0.00022653	2.23956	0.0028991

0.37	0.01	8750	0.0000199	0.00017462	2.4884	0.0024955
0.21	0.011	8750	0.0000197	9.9109E-05	2.73724	0.0015738
0	0.012	8750	0.0000198	0	2.98608	0

Copper / Cylinder / 10mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.66	0	10000	0.000036	0.00078343	0	0
1.59	0.001	10000	0.0000358	0.0007504	0.24884	0.0005216
1.53	0.002	10000	0.0000359	0.00072208	0.49768	0.001001
1.45	0.003	10000	0.0000358	0.00068432	0.74652	0.001427
1.38	0.004	10000	0.0000357	0.00065129	0.99536	0.0018159
1.33	0.005	10000	0.0000357	0.00062769	1.2442	0.0021876
1.24	0.006	10000	0.0000357	0.00058521	1.49304	0.0024475
1.13	0.007	10000	0.0000356	0.0005333	1.74188	0.0026094
1.06	0.008	10000	0.0000357	0.00050026	1.99072	0.0027896
0.98	0.009	10000	0.0000356	0.00046251	2.23956	0.0029096
0.83	0.01	10000	0.0000356	0.00039172	2.4884	0.0027381
0.74	0.011	10000	0.0000356	0.00034924	2.73724	0.0026853
0.6	0.012	10000	0.0000356	0.00028317	2.98608	0.0023752
0.47	0.013	10000	0.0000355	0.00022182	3.23492	0.0020213
0.39	0.014	10000	0.0000355	0.00018406	3.48376	0.0018062
0.29	0.015	10000	0.0000351	0.00013686	3.7326	0.0014554
0.11	0.016	10000	0.0000351	5.1914E-05	3.98144	0.0005889
0	0.017	10000	0.0000351	0	4.23028	0

Copper / Cylinder / 15mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.12	0	10000	4.97E-06	0.00052858	0	0
1.08	0.001	10000	4.96E-06	0.0005097	0.24884	0.0025571
0.96	0.002	10000	4.83E-06	0.00045307	0.49768	0.0046684
0.85	0.003	10000	4.67E-06	0.00040115	0.74652	0.0064126
0.76	0.004	10000	4.67E-06	0.00035868	0.99536	0.0076449
0.65	0.005	10000	4.82E-06	0.00030677	1.2442	0.0079186
0.54	0.006	10000	4.69E-06	0.00025485	1.49304	0.0081131
0.33	0.007	10000	4.55E-06	0.00015574	1.74188	0.0059623
0.12	0.008	10000	4.54E-06	5.6634E-05	1.99072	0.0024833

0	0.009	10000	0.0000046	0	2.23956	0

Copper / Cylinder / 15mm / 12,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.71	0	12500	0.0000339	0.00080703	0	0
1.63	0.001	12500	0.0000337	0.00076927	0.24884	0.0004544
1.57	0.002	12500	0.0000339	0.00074096	0.49768	0.0008702
1.49	0.003	12500	0.0000336	0.0007032	0.74652	0.0012499
1.45	0.004	12500	0.0000336	0.00068432	0.99536	0.0016218
1.36	0.005	12500	0.0000333	0.00064185	1.2442	0.0019185
1.28	0.006	12500	0.0000328	0.00060409	1.49304	0.0021998
1.19	0.007	12500	0.0000336	0.00056162	1.74188	0.0023292
1.15	0.008	12500	0.0000332	0.00054274	1.99072	0.0026035
1.06	0.009	12500	0.0000338	0.00050026	2.23956	0.0026518
0.91	0.01	12500	0.000034	0.00042947	2.4884	0.0025146
0.79	0.011	12500	0.0000337	0.00037284	2.73724	0.0024227
0.67	0.012	12500	0.0000339	0.0003162	2.98608	0.0022282
0.53	0.013	12500	0.0000333	0.00025013	3.23492	0.0019439
0.45	0.014	12500	0.0000337	0.00021238	3.48376	0.0017564
0.31	0.015	12500	0.0000339	0.0001463	3.7326	0.0012887
0.17	0.016	12500	0.0000339	8.0231E-05	3.98144	0.0007538
0	0.017	12500	0.0000341	0	4.23028	0

Copper / Cylinder / 15mm / 15,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.01	0	15000	0.000174	0.00094861	0	0
1.97	0.001	15000	0.00017	0.00092974	0.24884	9.073E-05
1.91	0.002	15000	0.00017	0.00090142	0.49768	0.0001759
1.86	0.003	15000	0.000169	0.00087782	0.74652	0.0002585
1.77	0.004	15000	0.00017	0.00083535	0.99536	0.0003261
1.73	0.005	15000	0.000162	0.00081647	1.2442	0.000418
1.68	0.006	15000	0.000157	0.00079287	1.49304	0.0005027
1.61	0.007	15000	0.000157	0.00075983	1.74188	0.000562
1.57	0.008	15000	0.000154	0.00074096	1.99072	0.0006385
1.53	0.009	15000	0.000154	0.00072208	2.23956	0.0007001

1.44	0.01	15000	0.000157	0.0006796	2.4884	0.0007181
1.38	0.011	15000	0.000154	0.00065129	2.73724	0.0007717
1.3	0.012	15000	0.000155	0.00061353	2.98608	0.000788
1.26	0.013	15000	0.000157	0.00059465	3.23492	0.0008168
1.18	0.014	15000	0.000157	0.0005569	3.48376	0.0008238
1.14	0.015	15000	0.000157	0.00053802	3.7326	0.0008527
1.06	0.016	15000	0.000157	0.00050026	3.98144	0.0008458
0.97	0.017	15000	0.000157	0.00045779	4.23028	0.0008223
0.91	0.018	15000	0.000158	0.00042947	4.47912	0.0008117
0.72	0.019	15000	0.000159	0.0003398	4.72796	0.0006736
0.63	0.02	15000	0.000158	0.00029733	4.9768	0.0006244
0.55	0.021	15000	0.000158	0.00025957	5.22564	0.0005723
0.4	0.022	15000	0.000159	0.00018878	5.47448	0.0004333
0.26	0.023	15000	0.000159	0.00012271	5.72332	0.0002945
0.15	0.024	15000	0.000158	7.0792E-05	5.97216	0.0001784
0	0.025	15000	0.000159	0	6.221	0

Copper / Cylinder / 20mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
0.8	0	10000	4.19E-07	0.00037756	0	0
0.69	0.001	10000	4.18E-07	0.00032564	0.24884	0.0193859
0.58	0.002	10000	4.17E-07	0.00027373	0.49768	0.032669
0.44	0.003	10000	4.18E-07	0.00020766	0.74652	0.0370861
0.29	0.004	10000	4.17E-07	0.00013686	0.99536	0.032669
0.12	0.005	10000	4.17E-07	5.6634E-05	1.2442	0.0168977
0	0.006	10000	4.17E-07	0	1.49304	0

Copper / Cylinder / 20mm / 15,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.52	0	15000	0.0000266	0.00071736	0	0
1.46	0.001	15000	0.0000264	0.00068904	0.24884	0.000433
1.4	0.002	15000	0.0000264	0.00066073	0.49768	0.0008304
1.34	0.003	15000	0.0000268	0.00063241	0.74652	0.0011744
1.28	0.004	15000	0.000027	0.00060409	0.99536	0.0014847
1.19	0.005	15000	0.0000269	0.00056162	1.2442	0.0017318

1.12	0.006	15000	0.0000271	0.00052858	1.49304	0.0019414
1.05	0.007	15000	0.0000271	0.00049554	1.74188	0.0021234
0.94	0.008	15000	0.000027	0.00044363	1.99072	0.0021806
0.85	0.009	15000	0.0000275	0.00040115	2.23956	0.002178
0.73	0.01	15000	0.0000279	0.00034452	2.4884	0.0020485
0.6	0.011	15000	0.0000278	0.00028317	2.73724	0.0018588
0.47	0.012	15000	0.0000281	0.00022182	2.98608	0.0015714
0.22	0.013	15000	0.0000281	0.00010383	3.23492	0.0007969
0.09	0.014	15000	0.0000273	4.2475E-05	3.48376	0.0003614
0	0.015	15000	0.0000271	0	3.7326	0

Copper / Cylinder / 20mm / 17,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.87	0	17500	0.000109	0.00088254	0	0
1.83	0.001	17500	0.000108	0.00086366	0.24884	0.0001137
1.77	0.002	17500	0.000108	0.00083535	0.49768	0.00022
1.71	0.003	17500	0.000108	0.00080703	0.74652	0.0003188
1.66	0.004	17500	0.00011	0.00078343	0.99536	0.0004051
1.58	0.005	17500	0.00011	0.00074568	1.2442	0.000482
1.53	0.006	17500	0.000111	0.00072208	1.49304	0.000555
1.46	0.007	17500	0.000111	0.00068904	1.74188	0.0006179
1.42	0.008	17500	0.000108	0.00067016	1.99072	0.0007059
1.38	0.009	17500	0.000109	0.00065129	2.23956	0.0007647
1.32	0.01	17500	0.000106	0.00062297	2.4884	0.0008357
1.25	0.011	17500	0.000106	0.00058993	2.73724	0.0008705
1.18	0.012	17500	0.000107	0.0005569	2.98608	0.0008881
1.07	0.013	17500	0.000107	0.00050498	3.23492	0.0008724
1.01	0.014	17500	0.000108	0.00047667	3.48376	0.0008786
0.91	0.015	17500	0.000107	0.00042947	3.7326	0.0008561
0.82	0.016	17500	0.000108	0.000387	3.98144	0.0008152
0.73	0.017	17500	0.000108	0.00034452	4.23028	0.0007711
0.54	0.018	17500	0.000108	0.00025485	4.47912	0.000604
0.31	0.019	17500	0.000107	0.0001463	4.72796	0.0003694
0.11	0.02	17500	0.000108	5.1914E-05	4.9768	0.0001367
0	0.021	17500	0.000109	0	5.22564	0

Conductive Graphite / Cylinder / 10mm / 11,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.79	0	11000	0.0000642	0.00084479	0	0
1.76	0.001	11000	0.0000639	0.00083063	0.24884	0.0002941
1.74	0.002	11000	0.0000638	0.00082119	0.49768	0.0005823
1.67	0.003	11000	0.0000636	0.00078815	0.74652	0.000841
1.62	0.004	11000	0.0000633	0.00076455	0.99536	0.0010929
1.58	0.005	11000	0.0000632	0.00074568	1.2442	0.0013345
1.5	0.006	11000	0.000063	0.00070792	1.49304	0.0015252
1.46	0.007	11000	0.0000621	0.00068904	1.74188	0.001757
1.39	0.008	11000	0.000063	0.00065601	1.99072	0.0018845
1.33	0.009	11000	0.0000626	0.00062769	2.23956	0.0020415
1.24	0.01	11000	0.0000626	0.00058521	2.4884	0.0021148
1.17	0.011	11000	0.0000626	0.00055218	2.73724	0.002195
1.08	0.012	11000	0.0000625	0.0005097	2.98608	0.0022138
0.99	0.013	11000	0.0000625	0.00046723	3.23492	0.0021985
0.92	0.014	11000	0.0000613	0.00043419	3.48376	0.0022432
0.84	0.015	11000	0.0000616	0.00039644	3.7326	0.0021838
0.78	0.016	11000	0.0000617	0.00036812	3.98144	0.0021595
0.67	0.017	11000	0.0000607	0.0003162	4.23028	0.0020033
0.6	0.018	11000	0.0000608	0.00028317	4.47912	0.0018964
0.51	0.019	11000	0.0000607	0.00024069	4.72796	0.0017043
0.46	0.02	11000	0.0000607	0.0002171	4.9768	0.0016182
0.25	0.021	11000	0.0000605	0.00011799	5.22564	0.0009265
0.11	0.022	11000	0.0000604	5.1914E-05	5.47448	0.0004278
0	0.023	11000	0.0000604	0	5.72332	0

Conductive Graphite / Cylinder / 10mm / 12,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.05	0	12000	0.0000815	0.00096749	0	0
2.02	0.001	12001	0.0000815	0.00095333	0.24884	0.0002425
1.99	0.002	12001	0.0000815	0.00093917	0.49768	0.0004779
1.94	0.003	12001	0.0000815	0.00091558	0.74652	0.0006988
1.89	0.004	12001	0.0000812	0.00089198	0.99536	0.0009111
1.84	0.005	12000	0.0000811	0.00086838	1.2442	0.0011102
1.81	0.006	12001	0.000081	0.00085422	1.49304	0.001312

1.77	0.007	12000	0.0000809	0.00083535	1.74188	0.0014988
1.69	0.008	12000	0.0000807	0.00079759	1.99072	0.0016396
1.65	0.009	12000	0.0000804	0.00077871	2.23956	0.0018076
1.6	0.01	12000	0.0000805	0.00075512	2.4884	0.0019452
1.53	0.011	12000	0.0000804	0.00072208	2.73724	0.0020486
1.45	0.012	12000	0.0000804	0.00068432	2.98608	0.002118
1.4	0.013	12000	0.0000802	0.00066073	3.23492	0.0022209
1.34	0.014	12000	0.0000796	0.00063241	3.48376	0.0023065
1.21	0.015	12000	0.0000799	0.00057106	3.7326	0.0022231
1.17	0.016	12000	0.0000798	0.00055218	3.98144	0.0022958
1.08	0.017	12000	0.0000796	0.0005097	4.23028	0.0022573
1.01	0.018	12000	0.0000795	0.00047667	4.47912	0.002238
0.93	0.019	12000	0.0000794	0.00043891	4.72796	0.002178
0.88	0.02	12000	0.0000795	0.00041531	4.9768	0.0021666
0.78	0.021	12000	0.0000802	0.00036812	5.22564	0.0019988
0.71	0.022	12000	0.0000801	0.00033508	5.47448	0.0019084
0.62	0.023	12000	0.0000809	0.00029261	5.72332	0.0017251
0.59	0.024	12000	0.0000804	0.00027845	5.97216	0.0017236
0.48	0.025	12000	0.0000816	0.00022653	6.221	0.0014392
0.33	0.026	12000	0.0000812	0.00015574	6.46984	0.0010341
0.18	0.027	12000	0.0000813	8.495E-05	6.71868	0.000585
0	0.028	12000	0.0000811	0	6.96752	0

Conductive Graphite / Cylinder / 10mm / 13,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.31	0	13000	0.000114	0.0010902	0	0
2.29	0.001	13000	0.000113	0.00108076	0.24884	0.0001831
2.23	0.002	13000	0.000113	0.00105244	0.49768	0.0003566
2.21	0.003	13000	0.000113	0.001043	0.74652	0.00053
2.17	0.004	13000	0.000113	0.00102412	0.99536	0.0006939
2.11	0.005	13000	0.000113	0.00099581	1.2442	0.0008434
2.07	0.006	13000	0.000113	0.00097693	1.49304	0.0009929
2.04	0.007	13000	0.000112	0.00096277	1.74188	0.0011518
2.02	0.008	13000	0.000112	0.00095333	1.99072	0.0013034
1.97	0.009	13000	0.000112	0.00092974	2.23956	0.0014301
1.93	0.01	13000	0.000112	0.00091086	2.4884	0.0015567
1.9	0.011	13000	0.000112	0.0008967	2.73724	0.0016858
1.84	0.012	13000	0.000112	0.00086838	2.98608	0.0017809

1.78	0.013	13000	0.000112	0.00084007	3.23492	0.0018664
1.75	0.014	13000	0.000112	0.00082591	3.48376	0.0019761
1.64	0.015	13000	0.000112	0.00077399	3.7326	0.0019842
1.62	0.016	13000	0.000112	0.00076455	3.98144	0.0020907
1.52	0.017	13000	0.000112	0.00071736	4.23028	0.0020842
1.44	0.018	13000	0.000113	0.0006796	4.47912	0.0020722
1.36	0.019	13000	0.000113	0.00064185	4.72796	0.0020658
1.31	0.02	13000	0.000113	0.00061825	4.9768	0.0020946
1.23	0.021	13000	0.000112	0.00058049	5.22564	0.0020834
1.16	0.022	13000	0.000113	0.00054746	5.47448	0.0020402
1.09	0.023	13000	0.000113	0.00051442	5.72332	0.0020042
1.03	0.024	13000	0.000113	0.00048611	5.97216	0.0019762
0.97	0.025	13000	0.000112	0.00045779	6.221	0.001956
0.88	0.026	13000	0.000114	0.00041531	6.46984	0.0018131
0.83	0.027	13000	0.000114	0.00039172	6.71868	0.0017759
0.77	0.028	13000	0.000112	0.0003634	6.96752	0.001739
0.67	0.029	13000	0.000113	0.0003162	7.21636	0.0015533
0.59	0.03	13000	0.000113	0.00027845	7.4652	0.001415
0.52	0.031	13000	0.000113	0.00024541	7.71404	0.0012887
0.4	0.032	13000	0.000114	0.00018878	7.96288	0.0010143
0.28	0.033	13000	0.000114	0.00013215	8.21172	0.0007322
0	0.034	13000	0.000114	0	8.46056	0

Conductive Graphite / Cylinder / 15mm / 15,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.27	0	15000	0.000082	0.0010713	0	0
2.21	0.002	15000	7.68E-05	0.001043	0.49768	0.000451
2.16	0.003	15000	7.51E-05	0.0010194	0.74652	0.000676
2.12	0.004	15000	7.48E-05	0.0010005	0.99536	0.000888
2.08	0.005	15000	7.36E-05	0.0009816	1.2442	0.001106
2.01	0.006	15000	0.000074	0.0009486	1.49304	0.001276
1.96	0.007	15000	7.41E-05	0.000925	1.74188	0.00145
1.92	0.008	15000	7.34E-05	0.0009061	1.99072	0.001638
1.89	0.009	15000	7.37E-05	0.000892	2.23956	0.001807
1.81	0.01	15000	7.36E-05	0.0008542	2.4884	0.001925
1.77	0.011	15000	7.28E-05	0.0008353	2.73724	0.002094
1.72	0.012	15000	7.37E-05	0.0008117	2.98608	0.002193
1.68	0.013	15000	0.000073	0.0007929	3.23492	0.002342

1.57	0.014	15000	7.33E-05	0.000741	3.48376	0.002348
1.51	0.015	15000	7.34E-05	0.0007126	3.7326	0.002416
1.46	0.016	15000	7.31E-05	0.000689	3.98144	0.002502
1.37	0.017	15000	7.29E-05	0.0006466	4.23028	0.002501
1.26	0.018	15000	7.26E-05	0.0005947	4.47912	0.002446
1.21	0.019	15000	7.23E-05	0.0005711	4.72796	0.00249
1.09	0.02	15000	7.35E-05	0.0005144	4.9768	0.002322
0.98	0.021	15000	7.33E-05	0.0004625	5.22564	0.002198
0.93	0.022	15000	7.31E-05	0.0004389	5.47448	0.002191
0.84	0.023	15000	0.000073	0.0003964	5.72332	0.002072
0.71	0.024	15000	7.27E-05	0.0003351	5.97216	0.001835
0.63	0.025	15000	0.000073	0.0002973	6.221	0.001689
0.55	0.026	15000	7.32E-05	0.0002596	6.46984	0.001529
0.48	0.027	15000	7.33E-05	0.0002265	6.71868	0.001384
0.31	0.028	15000	7.33E-05	0.0001463	6.96752	0.000927
0.12	0.029	15000	0.000073	5.663E-05	7.21636	0.000373
0	0.03	15000	7.29E-05	0	7.4652	0

Conductive Graphite / Cylinder / 15mm / 16,750V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.45	0	16750	0.000109	0.0011563	0	0
2.42	0.001	16750	0.000114	0.0011421	0.24884	0.000149
2.39	0.002	16750	0.00011	0.001128	0.49768	0.000305
2.35	0.003	16750	0.000107	0.0011091	0.74652	0.000462
2.32	0.004	16750	0.000106	0.0010949	0.99536	0.000614
2.27	0.005	16750	0.000106	0.0010713	1.2442	0.000751
2.24	0.006	16750	0.000106	0.0010572	1.49304	0.000889
2.22	0.007	16750	0.000105	0.0010477	1.74188	0.001038
2.18	0.008	16750	0.000108	0.0010288	1.99072	0.001132
2.14	0.009	16750	0.000105	0.00101	2.23956	0.001286
2.12	0.01	16750	0.000104	0.0010005	2.4884	0.001429
2.06	0.011	16750	0.000103	0.0009722	2.73724	0.001542
2.01	0.012	16750	0.000105	0.0009486	2.98608	0.001611
1.94	0.013	16750	0.000102	0.0009156	3.23492	0.001734
1.91	0.014	16750	0.000102	0.0009014	3.48376	0.001838
1.85	0.015	16750	0.000102	0.0008731	3.7326	0.001907
1.79	0.016	16750	0.000103	0.0008448	3.98144	0.00195
1.76	0.017	16750	0.000102	0.0008306	4.23028	0.002057

1.73	0.018	16750	0.000102	0.0008165	4.47912	0.002141
1.68	0.019	16750	0.000101	0.0007929	4.72796	0.002216
1.61	0.02	16750	0.000102	0.0007598	4.9768	0.002213
1.5	0.021	16750	0.000101	0.0007079	5.22564	0.002187
1.42	0.022	16750	0.000101	0.0006702	5.47448	0.002169
1.3	0.023	16750	0.000101	0.0006135	5.72332	0.002076
1.22	0.024	16750	0.000103	0.0005758	5.97216	0.001993
1.16	0.025	16750	0.000103	0.0005475	6.221	0.001974
1.09	0.026	16750	0.000101	0.0005144	6.46984	0.001967
1.01	0.027	16750	0.000103	0.0004767	6.71868	0.001856
0.93	0.028	16750	0.000102	0.0004389	6.96752	0.00179
0.87	0.029	16750	0.000105	0.0004106	7.21636	0.001685
0.72	0.03	16750	0.000106	0.0003398	7.4652	0.001429
0.59	0.031	16750	0.000108	0.0002784	7.71404	0.001187
0.56	0.032	16750	0.000105	0.0002643	7.96288	0.001197
0.48	0.033	16750	0.000106	0.0002265	8.21172	0.001048
0.29	0.034	16750	0.000106	0.0001369	8.46056	0.000652
0	0.035	16750	0.000106	0	8.7094	0

Conductive Graphite / Cylinder / 15mm / 18,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.62	0	18000	0.00034	0.0012365	0	0
2.59	0.001	18000	0.000336	0.0012223	0.24884	5.03E-05
2.54	0.002	18000	0.000329	0.0011987	0.49768	0.000101
2.52	0.003	18000	0.000328	0.0011893	0.74652	0.00015
2.47	0.004	18000	0.000326	0.0011657	0.99536	0.000198
2.44	0.005	18000	0.000292	0.0011516	1.2442	0.000273
2.42	0.006	18000	0.000252	0.0011421	1.49304	0.000376
2.39	0.007	18000	0.000239	0.001128	1.74188	0.000457
2.37	0.008	18000	0.000247	0.0011185	1.99072	0.000501
2.35	0.009	18000	0.000238	0.0011091	2.23956	0.00058
2.32	0.01	18000	0.000245	0.0010949	2.4884	0.000618
2.27	0.011	18000	0.000232	0.0010713	2.73724	0.000702
2.2	0.012	18000	0.000223	0.0010383	2.98608	0.000772
2.16	0.013	18000	0.000225	0.0010194	3.23492	0.000814
2.13	0.014	18000	0.000222	0.0010052	3.48376	0.000876
2.07	0.015	18000	0.000226	0.0009769	3.7326	0.000896
2.03	0.016	18000	0.000218	0.0009581	3.98144	0.000972

1.99	0.017	18000	0.000225	0.0009392	4.23028	0.000981
1.97	0.018	18000	0.000216	0.0009297	4.47912	0.001071
1.94	0.019	18000	0.000218	0.0009156	4.72796	0.001103
1.9	0.02	18000	0.000218	0.0008967	4.9768	0.001137
1.85	0.021	18000	0.000211	0.0008731	5.22564	0.001201
1.78	0.022	18000	0.000214	0.0008401	5.47448	0.001194
1.73	0.023	18000	0.00022	0.0008165	5.72332	0.00118
1.67	0.024	18000	0.000215	0.0007882	5.97216	0.001216
1.58	0.025	18000	0.000222	0.0007457	6.221	0.001161
1.51	0.026	18000	0.000218	0.0007126	6.46984	0.001175
1.44	0.027	18000	0.000219	0.0006796	6.71868	0.001158
1.35	0.028	18000	0.000212	0.0006371	6.96752	0.001163
1.29	0.029	18000	0.00023	0.0006088	7.21636	0.001061
1.12	0.03	18000	0.000224	0.0005286	7.4652	0.000979
1.04	0.031	18000	0.000209	0.0004908	7.71404	0.001006
0.98	0.032	18000	0.00021	0.0004625	7.96288	0.000974
0.92	0.033	18000	0.000213	0.0004342	8.21172	0.00093
0.85	0.034	18000	0.000218	0.0004012	8.46056	0.000865
0.74	0.035	18000	0.000215	0.0003492	8.7094	0.000786
0.63	0.036	18000	0.000218	0.0002973	8.95824	0.000679
0.52	0.037	18000	0.000222	0.0002454	9.20708	0.000565
0.44	0.038	18000	0.000218	0.0002077	9.45592	0.0005
0.33	0.039	18000	0.000224	0.0001557	9.70476	0.000375
0.21	0.04	18000	0.000231	9.911E-05	9.9536	0.000237
0	0.041	18000	0.00023	0	10.20244	0

Conductive Graphite / Cylinder / 20mm / 17,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.08	0	17500	0.00005	0.000982	0	0
2.01	0.002	17500	4.82E-05	0.000949	0.49768	0.000559699
1.97	0.003	17500	4.78E-05	0.00093	0.74652	0.000829726
1.89	0.004	17500	4.85E-05	0.000892	0.99536	0.001046057
1.83	0.005	17500	4.84E-05	0.000864	1.2442	0.001268677
1.79	0.006	17500	4.84E-05	0.000845	1.49304	0.001489136
1.74	0.007	17500	4.85E-05	0.000821	1.74188	0.001685314
1.69	0.008	17500	4.79E-05	0.000798	1.99072	0.00189416
1.62	0.009	17500	4.86E-05	0.000765	2.23956	0.002013245
1.55	0.01	17500	4.93E-05	0.000732	2.4884	0.002109892

1.46	0.011	17500	4.89E-05	0.000689	2.73724	0.002204002
1.38	0.012	17500	4.91E-05	0.000651	2.98608	0.002263363
1.304	0.013	17500	4.94E-05	0.000615	3.23492	0.00230287
1.22	0.014	17500	4.93E-05	0.000576	3.48376	0.002324964
1.16	0.015	17500	5.04E-05	0.000547	3.7326	0.00231683
0.98	0.016	17500	5.02E-05	0.000463	3.98144	0.002096128
0.87	0.017	17500	4.99E-05	0.000411	4.23028	0.001989038
0.73	0.018	17500	4.96E-05	0.000345	4.47912	0.001777825
0.61	0.019	17500	4.97E-05	0.000288	4.72796	0.001564957
0.54	0.02	17500	5.02E-05	0.000255	4.9768	0.001443761
0.43	0.021	17500	4.89E-05	0.000203	5.22564	0.001239237
0.23	0.022	17500	4.91E-05	0.000109	5.47448	0.000691583
0	0.023	17500	4.92E-05	0	5.72332	0

Conductive Graphite / Cylinder / 20mm / 19,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.23	0	19500	0.000082	0.001052	0	0
2.2	0.001	19500	8.13E-05	0.001038	0.24884	0.000162971
2.17	0.002	19500	8.06E-05	0.001024	0.49768	0.00032429
2.13	0.003	19501	8.08E-05	0.001005	0.74652	0.000476262
2.08	0.004	19500	7.96E-05	0.000982	0.99536	0.00062949
2.03	0.005	19500	8.01E-05	0.000958	1.2442	0.000763154
2	0.006	19501	7.99E-05	0.000944	1.49304	0.000904463
1.96	0.007	19500	7.96E-05	0.000925	1.74188	0.001038054
1.92	0.008	19500	7.96E-05	0.000906	1.99072	0.001162136
1.87	0.009	19500	7.93E-05	0.000883	2.23956	0.001278173
1.78	0.01	19500	7.76E-05	0.00084	2.4884	0.001381456
1.75	0.011	19500	7.87E-05	0.000826	2.73724	0.001473109
1.69	0.012	19500	7.94E-05	0.000798	2.98608	0.001538248
1.65	0.013	19500	7.91E-05	0.000779	3.23492	0.001633163
1.56	0.014	19500	8.05E-05	0.000736	3.48376	0.001633938
1.49	0.015	19500	8.08E-05	0.000703	3.7326	0.001665885
1.43	0.016	19500	8.11E-05	0.000675	3.98144	0.001699081
1.39	0.017	19500	8.14E-05	0.000656	4.23028	0.001748309
1.28	0.018	19500	0.000082	0.000604	4.47912	0.001692183
1.2	0.019	19500	8.24E-05	0.000566	4.72796	0.001666428
1.11	0.02	19500	8.35E-05	0.000524	4.9768	0.001601199
0.98	0.021	19500	8.23E-05	0.000463	5.22564	0.001505998
0.89	0.022	19500	8.26E-05	0.00042	5.47448	0.001427616

0.75	0.023	19500	8.34E-05	0.000354	5.72332	0.001245667
0.63	0.024	19500	8.39E-05	0.000297	5.97216	0.001085347
0.46	0.025	19500	8.44E-05	0.000217	6.221	0.000820605
0.27	0.026	19500	8.74E-05	0.000127	6.46984	0.000483732
0	0.027	19500	0.000088	0	6.71868	0

Conductive Graphite / Cylinder / 20mm / 20,750V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m^3/s	N/m^2	η
2.43	0	20751	0.000147	0.00114683	0	0
2.38	0.001	20751	0.000146	0.00112323	0.24884	9.22568E-05
2.31	0.002	20751	0.000144	0.0010902	0.49768	0.000181574
2.29	0.003	20751	0.000143	0.00108076	0.74652	0.000271891
2.24	0.004	20751	0.000139	0.00105716	0.99536	0.000364811
2.21	0.005	20751	0.000139	0.001043	1.2442	0.000449906
2.18	0.006	20752	0.000139	0.00102884	1.49304	0.000532533
2.16	0.007	20750	0.000141	0.00101941	1.74188	0.000606915
2.13	0.008	20750	0.000141	0.00100525	1.99072	0.000683984
2.09	0.009	20750	0.00014	0.00098637	2.23956	0.000760424
2.01	0.01	20750	0.000139	0.00094861	2.4884	0.000818421
1.97	0.011	20750	0.000139	0.00092974	2.73724	0.000882347
1.94	0.012	20750	0.000138	0.00091558	2.98608	0.000954771
1.9	0.013	20750	0.00014	0.0008967	3.23492	0.000998537
1.86	0.014	20750	0.000139	0.00087782	3.48376	0.001060282
1.78	0.015	20750	0.000141	0.00084007	3.7326	0.001071735
1.71	0.016	20750	0.00014	0.00080703	3.98144	0.001106072
1.66	0.017	20750	0.000141	0.00078343	4.23028	0.001132748
1.62	0.018	20750	0.000142	0.00076455	4.47912	0.001162236
1.57	0.019	20750	0.000139	0.00074096	4.72796	0.001214601
1.46	0.02	20750	0.000143	0.00068904	4.9768	0.001155692
1.4	0.021	20750	0.000144	0.00066073	5.22564	0.001155527
1.32	0.022	20750	0.000144	0.00062297	5.47448	0.001141378
1.17	0.023	20750	0.000144	0.00055218	5.72332	0.001057661
1.1	0.024	20750	0.000146	0.00051914	5.97216	0.001023402
0.93	0.025	20750	0.000146	0.00043891	6.221	0.000901292
0.89	0.026	20750	0.000147	0.00042003	6.46984	0.000890925
0.75	0.027	20750	0.000146	0.00035396	6.71868	0.000784996
0.54	0.028	20750	0.000146	0.00025485	6.96752	0.00058613
0.4	0.029	20750	0.000148	0.00018878	7.21636	0.0004436

0.32	0.03	20750	0.000148	0.00015102	7.4652	0.000367117
0.14	0.031	20750	0.000149	6.6073E-05	7.71404	0.000164854
0	0.032	20750	0.000149	0	7.96288	0

Conductive Graphite / Conical / 10mm / 11,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.09	0	11000	0.000207	0.000986369	0	0
2.02	0.001	11000	0.000208	0.000953333	0.24884	0.000103683
1.98	0.002	11000	0.000207	0.000934455	0.49768	0.000204242
1.95	0.003	11000	0.000207	0.000920297	0.74652	0.000301721
1.91	0.004	11000	0.000209	0.000901419	0.99536	0.000390272
1.85	0.005	11000	0.000208	0.000873102	1.2442	0.000474787
1.82	0.006	11000	0.000208	0.000858944	1.49304	0.000560506
1.78	0.007	11000	0.000207	0.000840066	1.74188	0.000642641
1.71	0.008	11000	0.000208	0.000807029	1.99072	0.000702172
1.67	0.009	11000	0.000207	0.000788151	2.23956	0.000775192
1.58	0.01	11000	0.000207	0.000745676	2.4884	0.000814906
1.53	0.011	11000	0.000208	0.000722079	2.73724	0.000863856
1.47	0.012	11000	0.000208	0.000693762	2.98608	0.000905432
1.42	0.013	11000	0.000209	0.000670165	3.23492	0.000942988
1.38	0.014	11000	0.000208	0.000651287	3.48376	0.000991664
1.29	0.015	11000	0.000208	0.000608812	3.7326	0.000993204
1.24	0.016	11000	0.000208	0.000585214	3.98144	0.001018355
1.16	0.017	11000	0.000208	0.000547459	4.23028	0.001012195
1.05	0.018	11000	0.000209	0.000495544	4.47912	0.000965464
0.99	0.019	11000	0.000209	0.000467228	4.72796	0.000960867
0.92	0.02	11000	0.00021	0.000434191	4.9768	0.000935447
0.86	0.021	11000	0.000211	0.000405874	5.22564	0.00091381
0.63	0.022	11000	0.000213	0.000297327	5.47448	0.000694711
0.41	0.023	11000	0.000211	0.000193498	5.72332	0.000477145
0.32	0.024	11000	0.00021	0.000151023	5.97216	0.000390448
0.165	0.025	11000	0.000213	7.78713E-05	6.221	0.000206759
0	0.026	11000	0.000214	0	6.46984	0

Conductive Graphite / Conical / 10mm / 12,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.26	0	12000	0.000262	0.0010666	0	0
2.22	0.001	12000	0.000263	0.001047722	0.24884	8.26094E-05
2.18	0.002	12000	0.000264	0.001028844	0.49768	0.000161627
2.16	0.003	12000	0.000268	0.001019406	0.74652	0.000236631
2.09	0.004	12000	0.000266	0.000986369	0.99536	0.000307579
2.05	0.005	12000	0.000268	0.000967491	1.2442	0.000374301
2.03	0.006	12000	0.000268	0.000958052	1.49304	0.000444779
1.97	0.007	12000	0.000267	0.000929736	1.74188	0.000505458
1.93	0.008	12000	0.000266	0.000910858	1.99072	0.000568065
1.89	0.009	12000	0.000266	0.00089198	2.23956	0.000625828
1.83	0.01	12000	0.000266	0.000863663	2.4884	0.000673289
1.76	0.011	12000	0.000268	0.000830627	2.73724	0.000706973
1.74	0.012	12000	0.000269	0.000821188	2.98608	0.000759644
1.69	0.013	12000	0.000271	0.00079759	3.23492	0.000793401
1.65	0.014	12000	0.000271	0.000778713	3.48376	0.000834209
1.6	0.015	12000	0.000271	0.000755115	3.7326	0.000866711
1.56	0.016	12000	0.000271	0.000736237	3.98144	0.000901379
1.49	0.017	12000	0.000271	0.000703201	4.23028	0.000914741
1.45	0.018	12000	0.000271	0.000684323	4.47912	0.000942548
1.37	0.019	12000	0.000272	0.000646567	4.72796	0.000936564
1.32	0.02	12000	0.000272	0.00062297	4.9768	0.000949877
1.25	0.021	12000	0.000271	0.000589934	5.22564	0.000947965
1.19	0.022	12000	0.00027	0.000561617	5.47448	0.000948938
1.11	0.023	12000	0.000271	0.000523861	5.72332	0.000921963
1.03	0.024	12000	0.00027	0.000486105	5.97216	0.000896018
0.88	0.025	12000	0.000273	0.000415313	6.221	0.000788664
0.79	0.026	12000	0.000272	0.000372838	6.46984	0.000739033
0.54	0.027	12000	0.000271	0.000254851	6.71868	0.000526527
0.45	0.028	12000	0.000271	0.000212376	6.96752	0.000455023
0.36	0.029	12000	0.00027	0.000169901	7.21636	0.000378415
0.23	0.03	12000	0.000273	0.000108548	7.4652	0.000247354
0.15	0.031	12000	0.000278	7.07921E-05	7.71404	0.000163697
0	0.032	12000	0.000281	0	7.96288	0

Conductive Graphite / Conical / 10mm / 13,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.58	0	13000	0.000344	0.001217623	0	0
2.52	0.001	13000	0.000342	0.001189306	0.24884	6.65648E-05
2.47	0.002	13000	0.000343	0.001165709	0.49768	0.000130108
2.43	0.003	13000	0.000343	0.001146831	0.74652	0.000192001
2.39	0.004	13000	0.000348	0.001127953	0.99536	0.00024817
2.32	0.005	13000	0.000343	0.001094917	1.2442	0.000305516
2.29	0.006	13000	0.000346	0.001080759	1.49304	0.000358741
2.26	0.007	13000	0.000347	0.0010666	1.74188	0.000411858
2.22	0.008	13000	0.000346	0.001047722	1.99072	0.0004637
2.17	0.009	13000	0.000339	0.001024125	2.23956	0.000520442
2.14	0.01	13000	0.000346	0.001009967	2.4884	0.000558737
2.08	0.011	13000	0.000342	0.00098165	2.73724	0.000604366
2.04	0.012	13000	0.000331	0.000962772	2.98608	0.000668118
1.99	0.013	13000	0.000338	0.000939175	3.23492	0.000691433
1.96	0.014	13000	0.000343	0.000925016	3.48376	0.000722703
1.91	0.015	13000	0.000342	0.000901419	3.7326	0.000756778
1.88	0.016	13000	0.000342	0.00088726	3.98144	0.000794551
1.85	0.017	13000	0.00034	0.000873102	4.23028	0.000835626
1.78	0.018	13000	0.000341	0.000840066	4.47912	0.000848806
1.75	0.019	13000	0.000345	0.000825907	4.72796	0.000870648
1.68	0.02	13000	0.00035	0.000792871	4.9768	0.000867244
1.64	0.021	13000	0.000349	0.000773993	5.22564	0.000891472
1.59	0.022	13000	0.000349	0.000750396	5.47448	0.00090545
1.54	0.023	13000	0.00035	0.000726798	5.72332	0.00091422
1.46	0.024	13000	0.000347	0.000689043	5.97216	0.000912231
1.42	0.025	13000	0.000345	0.000670165	6.221	0.000929564
1.37	0.026	13000	0.000347	0.000646567	6.46984	0.00092733
1.3	0.027	13000	0.000344	0.000613531	6.71868	0.000921762
1.21	0.028	13000	0.000342	0.000571056	6.96752	0.000894926
1.17	0.029	13000	0.000348	0.000552178	7.21636	0.000880795
1.03	0.03	13000	0.000351	0.000486105	7.4652	0.000795283
0.96	0.031	13000	0.000354	0.000453069	7.71404	0.000759451
0.84	0.032	13000	0.000354	0.000396435	7.96288	0.000685956
0.63	0.033	13000	0.000353	0.000297327	8.21172	0.000532047
0.47	0.034	13000	0.000352	0.000221815	8.46056	0.000410114
0.39	0.035	13000	0.000352	0.000184059	8.7094	0.000350316
0.26	0.036	13000	0.000353	0.000122706	8.95824	0.000239536

0.18	0.037	13000	0.000361	8.49505E-05	9.20708	0.000166662
0	0.038	13000	0.000358	0	9.45592	0

Conductive Graphite / Conical / 15mm / 15,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.52	0	15000	0.000244	0.001189306	0	0
2.47	0.001	15000	0.000245	0.001165709	0.24884	7.8932E-05
2.43	0.002	15000	0.000242	0.001146831	0.49768	0.00015723
2.37	0.003	15000	0.000243	0.001118514	0.74652	0.00022908
2.32	0.004	15000	0.000241	0.001094917	0.99536	0.00030148
2.29	0.005	15000	0.000241	0.001080759	1.2442	0.00037197
2.27	0.006	15000	0.00024	0.00107132	1.49304	0.00044431
2.24	0.007	15000	0.000242	0.001057161	1.74188	0.00050729
2.16	0.008	15000	0.000246	0.001019406	1.99072	0.00054996
2.11	0.009	15000	0.000246	0.000995808	2.23956	0.00060438
2.07	0.01	15000	0.000244	0.00097693	2.4884	0.00066421
2.02	0.011	15000	0.000243	0.000953333	2.73724	0.00071591
1.98	0.012	15000	0.000242	0.000934455	2.98608	0.00076869
1.92	0.013	15000	0.000243	0.000906138	3.23492	0.00080419
1.9	0.014	15000	0.000241	0.000896699	3.48376	0.00086415
1.86	0.015	15000	0.000241	0.000877821	3.7326	0.00090638
1.83	0.016	15000	0.000239	0.000863663	3.98144	0.00095917
1.79	0.017	15000	0.000242	0.000844785	4.23028	0.00098448
1.72	0.018	15000	0.000242	0.000811749	4.47912	0.00100163
1.69	0.019	15000	0.000243	0.00079759	4.72796	0.00103456
1.6	0.02	15000	0.000245	0.000755115	4.9768	0.0010226
1.56	0.021	15000	0.000245	0.000736237	5.22564	0.00104689
1.51	0.022	15000	0.000241	0.00071264	5.47448	0.00107921
1.46	0.023	15000	0.00024	0.000689043	5.72332	0.00109545
1.39	0.024	15000	0.000239	0.000656006	5.97216	0.00109282
1.31	0.025	15000	0.00024	0.000618251	6.221	0.00106837
1.24	0.026	15000	0.000242	0.000585214	6.46984	0.00104304
1.03	0.027	15000	0.00024	0.000486105	6.71868	0.00090722
0.81	0.028	15000	0.000244	0.000382277	6.96752	0.00072774
0.75	0.029	15000	0.000246	0.00035396	7.21636	0.00069222
0.62	0.03	15000	0.000244	0.000292607	7.4652	0.00059682
0.48	0.031	15000	0.000248	0.000226535	7.71404	0.00046976
0.26	0.032	15000	0.000247	0.000122706	7.96288	0.00026372

0.17	0.033	15000	0.000245	8.0231E-05	8.21172	0.00017927
0	0.034	15000	0.000249	0	8.46056	0

Conductive Graphite / Conical / 15mm / 16,750V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.9	0	16750	0.000346	0.001368646	0	0
2.85	0.001	16750	0.000343	0.001345049	0.24884	5.8257E-05
2.79	0.002	16750	0.000342	0.001316732	0.49768	0.00011439
2.75	0.003	16750	0.000339	0.001297854	0.74652	0.00017063
2.71	0.004	16750	0.000339	0.001278976	0.99536	0.0002242
2.67	0.005	16750	0.000339	0.001260098	1.2442	0.00027611
2.64	0.006	16750	0.000342	0.00124594	1.49304	0.00032473
2.61	0.007	16750	0.000341	0.001231782	1.74188	0.00037565
2.58	0.008	16750	0.00034	0.001217623	1.99072	0.00042563
2.54	0.009	16750	0.000343	0.001198745	2.23956	0.00046728
2.52	0.01	16750	0.000342	0.001189306	2.4884	0.00051662
2.47	0.011	16750	0.000342	0.001165709	2.73724	0.00055701
2.42	0.012	16750	0.000339	0.001142112	2.98608	0.00060061
2.38	0.013	16750	0.00034	0.001123234	3.23492	0.00063803
2.34	0.014	16750	0.000338	0.001104356	3.48376	0.00067956
2.29	0.015	16750	0.000337	0.001080759	3.7326	0.00071465
2.26	0.016	16750	0.000342	0.0010666	3.98144	0.00074131
2.23	0.017	16750	0.000341	0.001052442	4.23028	0.00077947
2.18	0.018	16750	0.000344	0.001028844	4.47912	0.00079978
2.15	0.019	16750	0.000344	0.001014686	4.72796	0.00083259
2.12	0.02	16750	0.000345	0.001000528	4.9768	0.00086168
2.08	0.021	16750	0.000341	0.00098165	5.22564	0.0008981
2	0.022	16750	0.00034	0.000943894	5.47448	0.00090734
1.96	0.023	16750	0.000341	0.000925016	5.72332	0.00092689
1.93	0.024	16750	0.000346	0.000910858	5.97216	0.00093862
1.87	0.025	16750	0.000348	0.000882541	6.221	0.00094189
1.84	0.026	16750	0.00035	0.000868382	6.46984	0.00095834
1.77	0.027	16750	0.00035	0.000835346	6.71868	0.00095734
1.68	0.028	16750	0.000346	0.000792871	6.96752	0.00095321
1.63	0.029	16750	0.000343	0.000769274	7.21636	0.00096625
1.59	0.03	16750	0.000342	0.000750396	7.4652	0.00097789
1.51	0.031	16750	0.00034	0.00071264	7.71404	0.00096529
1.45	0.032	16750	0.000341	0.000684323	7.96288	0.00095403

1.33	0.033	16750	0.000346	0.00062769	8.21172	0.00088938
1.23	0.034	16750	0.000349	0.000580495	8.46056	0.00084015
1.08	0.035	16750	0.00035	0.000509703	8.7094	0.00075722
0.88	0.036	16750	0.000353	0.000415313	8.95824	0.00062923
0.76	0.037	16750	0.000352	0.00035868	9.20708	0.00056011
0.62	0.038	16750	0.000352	0.000292607	9.45592	0.00046928
0.51	0.039	16750	0.000354	0.000240693	9.70476	0.00039394
0.42	0.04	16750	0.000358	0.000198218	9.9536	0.00032902
0.34	0.041	16750	0.000358	0.000160462	10.20244	0.00027301
0.15	0.042	16750	0.000361	7.07921E-05	10.45128	0.00012236
0	0.043	16750	0.000363	0	10.70012	0

Conductive Graphite / Conical / 15mm / 18,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
3.15	0	18000	0.000414	0.001486633	0	0
3.12	0.001	18000	0.000412	0.001472475	0.24884	4.9408E-05
3.09	0.002	18000	0.000408	0.001458316	0.49768	9.8826E-05
3.04	0.003	18000	0.000405	0.001434719	0.74652	0.00014692
2.98	0.004	18000	0.000408	0.001406402	0.99536	0.00019061
2.95	0.005	18000	0.000408	0.001392244	1.2442	0.00023587
2.93	0.006	18000	0.000406	0.001382805	1.49304	0.00028251
2.89	0.007	18000	0.00041	0.001363927	1.74188	0.00032192
2.87	0.008	18000	0.000411	0.001354488	1.99072	0.00036448
2.84	0.009	18000	0.000411	0.001340329	2.23956	0.00040575
2.82	0.01	18000	0.000412	0.001330891	2.4884	0.00044657
2.76	0.011	18000	0.000415	0.001302574	2.73724	0.0004773
2.73	0.012	18000	0.000416	0.001288415	2.98608	0.0005138
2.71	0.013	18000	0.000413	0.001278976	3.23492	0.00055655
2.65	0.014	18000	0.000411	0.00125066	3.48376	0.00058894
2.63	0.015	18000	0.000412	0.001241221	3.7326	0.00062473
2.57	0.016	18000	0.000406	0.001212904	3.98144	0.0006608
2.51	0.017	18000	0.000414	0.001184587	4.23028	0.00067245
2.48	0.018	18000	0.000412	0.001170429	4.47912	0.00070692
2.46	0.019	18000	0.000411	0.00116099	4.72796	0.00074197
2.44	0.02	18000	0.00041	0.001151551	4.9768	0.00077656
2.4	0.021	18000	0.000408	0.001132673	5.22564	0.00080596
2.36	0.022	18000	0.000408	0.001113795	5.47448	0.00083026
2.29	0.023	18000	0.000411	0.001080759	5.72332	0.00083611

2.26	0.024	18000	0.000409	0.0010666	5.97216	0.00086524
2.24	0.025	18000	0.000408	0.001057161	6.221	0.00089551
2.17	0.026	18000	0.000413	0.001024125	6.46984	0.0008913
2.14	0.027	18000	0.00042	0.001009967	6.71868	0.00089757
2.08	0.028	18000	0.000412	0.00098165	6.96752	0.00092228
2.04	0.029	18000	0.000415	0.000962772	7.21636	0.00093008
1.99	0.03	18000	0.000415	0.000939175	7.4652	0.00093857
1.96	0.031	18000	0.000417	0.000925016	7.71404	0.00095065
1.91	0.032	18000	0.000418	0.000901419	7.96288	0.000954
1.86	0.033	18000	0.000415	0.000877821	8.21172	0.00096498
1.78	0.034	18000	0.000418	0.000840066	8.46056	0.00094463
1.72	0.035	18000	0.000414	0.000811749	8.7094	0.00094872
1.68	0.036	18000	0.000412	0.000792871	8.95824	0.00095776
1.55	0.037	18000	0.000415	0.000731518	9.20708	0.00090163
1.49	0.038	18000	0.000416	0.000703201	9.45592	0.00088801
1.35	0.039	18000	0.000413	0.000637128	9.70476	0.00083174
1.28	0.04	18000	0.000409	0.000604092	9.9536	0.00081675
1.15	0.041	18000	0.000413	0.000542739	10.20244	0.00074486
0.93	0.042	18000	0.000412	0.000438911	10.45128	0.00061855
0.84	0.043	18000	0.000411	0.000396435	10.70012	0.00057339
0.61	0.044	18000	0.00041	0.000287888	10.94896	0.00042711
0.47	0.045	18000	0.000417	0.000221815	11.1978	0.00033091
0.38	0.046	18000	0.000423	0.00017934	11.44664	0.00026961
0.22	0.047	18000	0.000427	0.000103828	11.69548	0.00015799
0.13	0.048	18000	0.000428	6.13531E-05	11.94432	9.5122E-05
0	0.049	18000	0.000429	0	12.19316	0

Conductive Graphite / Conical / 20mm / 17,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.63	0	17500	0.000228	0.001241221	0	0
2.57	0.001	17500	0.000225	0.001212904	0.24884	7.6652E-05
2.49	0.002	17500	0.000225	0.001175148	0.49768	0.00014853
2.46	0.003	17500	0.000225	0.00116099	0.74652	0.00022011
2.41	0.004	17500	0.000223	0.001137392	0.99536	0.0002901
2.39	0.005	17500	0.000226	0.001127953	1.2442	0.00035484
2.34	0.006	17500	0.000225	0.001104356	1.49304	0.00041875
2.28	0.007	17500	0.000225	0.001076039	1.74188	0.00047602
2.25	0.008	17500	0.000227	0.001061881	1.99072	0.00053214

2.22	0.009	17500	0.000228	0.001047722	2.23956	0.00058808
2.19	0.01	17500	0.000227	0.001033564	2.4884	0.00064743
2.16	0.011	17500	0.000226	0.001019406	2.73724	0.00070553
2.12	0.012	17500	0.000226	0.001000528	2.98608	0.00075541
2.09	0.013	17500	0.000226	0.000986369	3.23492	0.00080678
2.05	0.014	17500	0.000227	0.000967491	3.48376	0.00084846
1.97	0.015	17500	0.000228	0.000929736	3.7326	0.00086976
1.94	0.016	17500	0.000227	0.000915577	3.98144	0.00091764
1.91	0.017	17500	0.000226	0.000901419	4.23028	0.00096416
1.84	0.018	17500	0.000227	0.000868382	4.47912	0.00097913
1.79	0.019	17500	0.000229	0.000844785	4.72796	0.00099666
1.76	0.02	17500	0.000231	0.000830627	4.9768	0.0010226
1.68	0.021	17500	0.00023	0.000792871	5.22564	0.00102938
1.64	0.022	17500	0.000227	0.000773993	5.47448	0.00106664
1.56	0.023	17500	0.000227	0.000736237	5.72332	0.00106072
1.48	0.024	17500	0.000229	0.000698482	5.97216	0.00104091
1.44	0.025	17500	0.000225	0.000679604	6.221	0.00107373
1.28	0.026	17500	0.000228	0.000604092	6.46984	0.00097954
1.15	0.027	17500	0.000226	0.000542739	6.71868	0.00092199
0.99	0.028	17500	0.000228	0.000467228	6.96752	0.00081589
0.94	0.029	17500	0.000229	0.00044363	7.21636	0.00079885
0.82	0.03	17500	0.000229	0.000386997	7.4652	0.0007209
0.71	0.031	17500	0.000228	0.000335082	7.71404	0.00064783
0.66	0.032	17500	0.00023	0.000311485	7.96288	0.00061623
0.47	0.033	17500	0.000232	0.000221815	8.21172	0.00044864
0.33	0.034	17500	0.000235	0.000155743	8.46056	0.00032041
0.24	0.035	17500	0.000237	0.000113267	8.7094	0.00023785
0.08	0.036	17500	0.000237	3.77558E-05	8.95824	8.1549E-05
0	0.037	17500	0.000239	0	9.20708	0

Conductive Graphite / Conical / 20mm / 19,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.89	0	19500	0.000305	0.001363927	0	0
2.83	0.001	19500	0.000303	0.00133561	0.24884	5.625E-05
2.79	0.002	19500	0.000308	0.001316732	0.49768	0.00010911
2.76	0.003	19500	0.000309	0.001302574	0.74652	0.00016138
2.72	0.004	19500	0.000309	0.001283696	0.99536	0.00021206
2.68	0.005	19500	0.00031	0.001264818	1.2442	0.00026033

2.65	0.006	19500	0.000307	0.00125066	1.49304	0.00031192
2.59	0.007	19500	0.000306	0.001222343	1.74188	0.00035682
2.55	0.008	19500	0.000308	0.001203465	1.99072	0.00039889
2.52	0.009	19500	0.000307	0.001189306	2.23956	0.00044492
2.5	0.01	19500	0.000307	0.001179868	2.4884	0.00049043
2.46	0.011	19500	0.000303	0.00116099	2.73724	0.00053785
2.42	0.012	19500	0.000306	0.001142112	2.98608	0.00057155
2.39	0.013	19500	0.000304	0.001127953	3.23492	0.00061553
2.37	0.014	19500	0.000305	0.001118514	3.48376	0.00065517
2.31	0.015	19500	0.000306	0.001090198	3.7326	0.00068196
2.28	0.016	19500	0.000304	0.001076039	3.98144	0.0007227
2.23	0.017	19500	0.000302	0.001052442	4.23028	0.00075601
2.18	0.018	19500	0.000302	0.001028844	4.47912	0.00078253
2.14	0.019	19500	0.000301	0.001009967	4.72796	0.00081354
2.1	0.02	19500	0.0003	0.000991089	4.9768	0.00084315
2.07	0.021	19500	0.0003	0.00097693	5.22564	0.00087266
2.02	0.022	19500	0.000297	0.000953333	5.47448	0.00090115
1.97	0.023	19500	0.000298	0.000929736	5.72332	0.00091571
1.94	0.024	19500	0.000301	0.000915577	5.97216	0.00093159
1.91	0.025	19500	0.0003	0.000901419	6.221	0.00095859
1.88	0.026	19500	0.000299	0.00088726	6.46984	0.00098455
1.79	0.027	19500	0.000306	0.000844785	6.71868	0.00095121
1.7	0.028	19500	0.000311	0.00080231	6.96752	0.00092178
1.63	0.029	19500	0.000311	0.000769274	7.21636	0.00091539
1.55	0.03	19500	0.00031	0.000731518	7.4652	0.00090338
1.43	0.031	19500	0.000311	0.000674884	7.71404	0.00085845
1.41	0.032	19500	0.000311	0.000665445	7.96288	0.00087375
1.33	0.033	19500	0.000307	0.00062769	8.21172	0.00086101
1.16	0.034	19500	0.000307	0.000547459	8.46056	0.00077371
1.04	0.035	19500	0.000309	0.000490825	8.7094	0.00070945
0.92	0.036	19500	0.000312	0.000434191	8.95824	0.00063931
0.78	0.037	19500	0.000311	0.000368119	9.20708	0.00055888
0.69	0.038	19500	0.000311	0.000325643	9.45592	0.00050775
0.58	0.039	19500	0.000312	0.000273729	9.70476	0.00043663
0.49	0.04	19500	0.000308	0.000231254	9.9536	0.00038325
0.38	0.041	19500	0.000312	0.00017934	10.20244	0.00030074
0.28	0.042	19500	0.000315	0.000132145	10.45128	0.00022484
0.14	0.043	19500	0.000315	6.60726E-05	10.70012	0.0001151
0	0.044	19500	0.000317	0	10.94896	0

Conductive Graphite / Conical / 20mm / 20,750V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
3.14	0	20750	0.000357	0.001481914	0	0
3.09	0.001	20750	0.000357	0.001458316	0.24884	4.8988E-05
3.04	0.002	20750	0.000356	0.001434719	0.49768	9.666E-05
2.98	0.003	20750	0.000356	0.001406402	0.74652	0.00014213
2.94	0.004	20750	0.000354	0.001387524	0.99536	0.00018802
2.9	0.005	20750	0.000355	0.001368646	1.2442	0.00023117
2.86	0.006	20750	0.000359	0.001349768	1.49304	0.00027053
2.83	0.007	20750	0.00036	0.00133561	1.74188	0.00031144
2.81	0.008	20750	0.000358	0.001326171	1.99072	0.00035539
2.79	0.009	20750	0.000358	0.001316732	2.23956	0.00039697
2.74	0.01	20750	0.000361	0.001293135	2.4884	0.00042957
2.72	0.011	20750	0.00036	0.001283696	2.73724	0.00047039
2.7	0.012	20750	0.000361	0.001274257	2.98608	0.00050796
2.67	0.013	20750	0.000361	0.001260098	3.23492	0.00054418
2.61	0.014	20750	0.00036	0.001231782	3.48376	0.00057446
2.58	0.015	20750	0.000361	0.001217623	3.7326	0.00060674
2.55	0.016	20750	0.000362	0.001203465	3.98144	0.00063789
2.52	0.017	20750	0.000363	0.001189306	4.23028	0.00066794
2.49	0.018	20750	0.000361	0.001175148	4.47912	0.00070268
2.46	0.019	20750	0.000362	0.00116099	4.72796	0.00073076
2.42	0.02	20750	0.000361	0.001142112	4.9768	0.00075881
2.37	0.021	20750	0.000361	0.001118514	5.22564	0.00078029
2.34	0.022	20750	0.000359	0.001104356	5.47448	0.0008116
2.31	0.023	20750	0.000361	0.001090198	5.72332	0.00083297
2.27	0.024	20750	0.000362	0.00107132	5.97216	0.00085177
2.22	0.025	20750	0.000363	0.001047722	6.221	0.00086533
2.19	0.026	20750	0.000364	0.001033564	6.46984	0.00088534
2.12	0.027	20750	0.000362	0.001000528	6.71868	0.00089492
2.08	0.028	20750	0.000362	0.00098165	6.96752	0.00091056
2.03	0.029	20750	0.000363	0.000958052	7.21636	0.00091787
1.98	0.03	20750	0.000364	0.000934455	7.4652	0.00092359
1.94	0.031	20750	0.000362	0.000915577	7.71404	0.00094026
1.83	0.032	20750	0.000362	0.000863663	7.96288	0.00091556
1.78	0.033	20750	0.00036	0.000840066	8.21172	0.00092348
1.72	0.034	20750	0.000361	0.000811749	8.46056	0.00091684
1.61	0.035	20750	0.000361	0.000759835	8.7094	0.00088345

1.54	0.036	20750	0.000362	0.000726798	8.95824	0.00086678
1.46	0.037	20750	0.000362	0.000689043	9.20708	0.00084458
1.32	0.038	20750	0.000363	0.00062297	9.45592	0.00078207
1.17	0.039	20750	0.000362	0.000552178	9.70476	0.00071341
1.07	0.04	20750	0.000363	0.000504983	9.9536	0.00066732
0.94	0.041	20750	0.000364	0.00044363	10.20244	0.00059925
0.85	0.042	20750	0.000361	0.000401155	10.45128	0.0005597
0.79	0.043	20750	0.000367	0.000372838	10.70012	0.00052387
0.71	0.044	20750	0.000368	0.000335082	10.94896	0.00048046
0.64	0.045	20750	0.000365	0.000302046	11.1978	0.00044658
0.52	0.046	20750	0.000364	0.000245412	11.44664	0.00037192
0.43	0.047	20750	0.00037	0.000202937	11.69548	0.00030914
0.32	0.048	20750	0.000371	0.000151023	11.94432	0.00023432
0.19	0.049	20750	0.00037	8.96699E-05	12.19316	0.00014241
0	0.05	20750	0.000372	0	12.442	0

Conductive Graphite / Parabolic / 10mm / 11,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.01	0	11000	0.000123	0.000948613	0	0
1.95	0.001	11000	0.000123	0.000920297	0.24884	0.000169258
1.91	0.002	11000	0.000123	0.000901419	0.49768	0.000331573
1.87	0.003	11000	0.000122	0.000882541	0.74652	0.000490935
1.84	0.004	11000	0.000122	0.000868382	0.99536	0.000644078
1.76	0.005	11000	0.000122	0.000830627	1.2442	0.000770094
1.72	0.006	11000	0.000123	0.000811749	1.49304	0.000895768
1.67	0.007	11000	0.000123	0.000788151	1.74188	0.001014682
1.58	0.008	11000	0.000124	0.000745676	1.99072	0.001088294
1.49	0.009	11000	0.000124	0.000703201	2.23956	0.00115459
1.43	0.01	11000	0.000124	0.000674884	2.4884	0.001231218
1.37	0.011	11000	0.000123	0.000646567	2.73724	0.001308064
1.32	0.012	11000	0.000123	0.00062297	2.98608	0.001374899
1.26	0.013	11000	0.000122	0.000594653	3.23492	0.001433424
1.15	0.014	11000	0.000123	0.000542739	3.48376	0.001397467
1.06	0.015	11000	0.000124	0.000500264	3.7326	0.001368977
1.01	0.016	11000	0.000123	0.000476666	3.98144	0.001402675
0.96	0.017	11000	0.000123	0.000453069	4.23028	0.001416563
0.84	0.018	11000	0.000123	0.000396435	4.47912	0.001312404
0.7	0.019	11000	0.000124	0.000330363	4.72796	0.001145119

0.57	0.02	11000	0.000125	0.00026901	4.9768	0.000973678
0.38	0.021	11000	0.000125	0.00017934	5.22564	0.000681575
0.27	0.022	11000	0.000125	0.000127426	5.47448	0.000507338
0	0.023	11000	0.000126	0	5.72332	0

Conductive Graphite / Parabolic / 10mm / 12,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.25	0	12000	0.000164	0.001061881	0	0
2.21	0.001	12000	0.000163	0.001043003	0.24884	0.00013269
2.17	0.002	12000	0.000162	0.001024125	0.49768	0.000262184
2.08	0.003	12000	0.000162	0.00098165	0.74652	0.000376966
2.02	0.004	12000	0.000163	0.000953333	0.99536	0.000485128
1.96	0.005	12000	0.000162	0.000925016	1.2442	0.000592029
1.93	0.006	12000	0.000161	0.000910858	1.49304	0.000703906
1.91	0.007	12000	0.000159	0.000901419	1.74188	0.000822937
1.87	0.008	12000	0.000162	0.000882541	1.99072	0.000903751
1.82	0.009	12000	0.000162	0.000858944	2.23956	0.000989535
1.77	0.01	12000	0.000162	0.000835346	2.4884	0.001069277
1.72	0.011	12000	0.000163	0.000811749	2.73724	0.001135967
1.67	0.012	12000	0.000163	0.000788151	2.98608	0.001203212
1.58	0.013	12000	0.000163	0.000745676	3.23492	0.001233233
1.51	0.014	12000	0.000163	0.00071264	3.48376	0.001269257
1.46	0.015	12000	0.000162	0.000689043	3.7326	0.001323004
1.4	0.016	12000	0.000161	0.000660726	3.98144	0.001361615
1.37	0.017	12000	0.000163	0.000646567	4.23028	0.001398344
1.24	0.018	12000	0.000163	0.000585214	4.47912	0.001340105
1.15	0.019	12000	0.000162	0.000542739	4.72796	0.001319984
1.1	0.02	12000	0.000163	0.000519142	4.9768	0.001320892
1.02	0.021	12000	0.000163	0.000481386	5.22564	0.001286068
0.92	0.022	12000	0.000162	0.000434191	5.47448	0.001222722
0.86	0.023	12000	0.000164	0.000405874	5.72332	0.00118036
0.65	0.024	12000	0.000165	0.000306766	5.97216	0.000925279
0.47	0.025	12000	0.000166	0.000221815	6.221	0.000692727
0.29	0.026	12000	0.000167	0.000136865	6.46984	0.000441862
0.12	0.027	12000	0.000169	5.66336E-05	6.71868	0.000187625
0	0.028	12000	0.000169	0	6.96752	0

Conductive Graphite / Parabolic / 10mm / 13,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.55	0	13000	0.000213	0.001203465	0	0
2.48	0.001	13000	0.000211	0.001170429	0.24884	0.000106179
2.41	0.002	13000	0.000209	0.001137392	0.49768	0.000208339
2.37	0.003	13000	0.000208	0.001118514	0.74652	0.000308799
2.33	0.004	13000	0.000207	0.001099637	0.99536	0.000406739
2.3	0.005	13000	0.000209	0.001085478	1.2442	0.000497075
2.26	0.006	13000	0.000209	0.0010666	1.49304	0.000586116
2.22	0.007	13000	0.000213	0.001047722	1.74188	0.000659085
2.16	0.008	13000	0.00021	0.001019406	1.99072	0.000743352
2.08	0.009	13000	0.000212	0.00098165	2.23956	0.000797701
2.05	0.01	13000	0.000211	0.000967491	2.4884	0.000877691
2.01	0.011	13000	0.000209	0.000948613	2.73724	0.00095568
1.95	0.012	13000	0.000213	0.000920297	2.98608	0.000992445
1.92	0.013	13000	0.000208	0.000906138	3.23492	0.001084055
1.88	0.014	13000	0.000207	0.00088726	3.48376	0.001148644
1.83	0.015	13000	0.000208	0.000863663	3.7326	0.0011922
1.76	0.016	13000	0.000209	0.000830627	3.98144	0.001217185
1.73	0.017	13000	0.000208	0.000816468	4.23028	0.001277326
1.65	0.018	13000	0.000209	0.000778713	4.47912	0.001283749
1.6	0.019	13000	0.000209	0.000755115	4.72796	0.001314006
1.53	0.02	13000	0.000208	0.000722079	4.9768	0.00132901
1.42	0.021	13000	0.000208	0.000670165	5.22564	0.001295133
1.38	0.022	13000	0.000209	0.000651287	5.47448	0.001312277
1.32	0.023	13000	0.000211	0.00062297	5.72332	0.001299838
1.24	0.024	13000	0.00021	0.000585214	5.97216	0.001280217
1.15	0.025	13000	0.000208	0.000542739	6.221	0.001248661
1.02	0.026	13000	0.000209	0.000481386	6.46984	0.001146297
0.96	0.027	13000	0.000208	0.000453069	6.71868	0.001125749
0.86	0.028	13000	0.000209	0.000405874	6.96752	0.001040831
0.69	0.029	13000	0.000211	0.000325643	7.21636	0.000856712
0.52	0.03	13000	0.000213	0.000245412	7.4652	0.00066163
0.35	0.031	13000	0.000215	0.000165181	7.71404	0.000455891
0.21	0.032	13000	0.000214	9.91089E-05	7.96288	0.000283678
0	0.033	13000	0.000215	0	8.21172	0

Conductive Graphite / Parabolic / 15mm / 15,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.5	0	15000	0.000171	0.001179868	0	0
2.44	0.001	15000	0.00017	0.001151551	0.24884	0.000112373
2.39	0.002	15000	0.00017	0.001127953	0.49768	0.000220141
2.31	0.003	15000	0.00017	0.001090198	0.74652	0.000319159
2.27	0.004	15000	0.000171	0.00107132	0.99536	0.000415731
2.24	0.005	15000	0.000171	0.001057161	1.2442	0.000512795
2.21	0.006	15000	0.00017	0.001043003	1.49304	0.000610684
2.17	0.007	15000	0.00017	0.001024125	1.74188	0.00069957
2.1	0.008	15000	0.00017	0.000991089	1.99072	0.000773718
2.07	0.009	15000	0.000169	0.00097693	2.23956	0.000863075
2.04	0.01	15000	0.00017	0.000962772	2.4884	0.000939514
2.01	0.011	15000	0.00017	0.000948613	2.73724	0.001018268
1.92	0.012	15000	0.000172	0.000906138	2.98608	0.00104876
1.87	0.013	15000	0.00017	0.000882541	3.23492	0.001119588
1.84	0.014	15000	0.000171	0.000868382	3.48376	0.001179429
1.77	0.015	15000	0.000172	0.000835346	3.7326	0.001208532
1.72	0.016	15000	0.00017	0.000811749	3.98144	0.001267423
1.67	0.017	15000	0.000171	0.000788151	4.23028	0.001299845
1.64	0.018	15000	0.000171	0.000773993	4.47912	0.001351582
1.58	0.019	15000	0.000172	0.000745676	4.72796	0.001366484
1.55	0.02	15000	0.000171	0.000731518	4.9768	0.001419344
1.46	0.021	15000	0.000169	0.000689043	5.22564	0.00142039
1.38	0.022	15000	0.000172	0.000651287	5.47448	0.00138196
1.25	0.023	15000	0.000173	0.000589934	5.72332	0.00130111
1.19	0.024	15000	0.000173	0.000561617	5.97216	0.001292511
1.08	0.025	15000	0.000173	0.000509703	6.221	0.001221912
0.95	0.026	15000	0.000172	0.00044835	6.46984	0.001124322
0.87	0.027	15000	0.000172	0.000410594	6.71868	0.001069244
0.73	0.028	15000	0.000174	0.000344521	6.96752	0.000919716
0.55	0.029	15000	0.000173	0.000259571	7.21636	0.000721833
0.42	0.03	15000	0.000174	0.000198218	7.4652	0.000566948
0.29	0.031	15000	0.000175	0.000136865	7.71404	0.000402202
0.13	0.032	15000	0.000175	6.13531E-05	7.96288	0.000186113
0	0.033	15000	0.000176	0	8.21172	0

Conductive Graphite / Parabolic / 15mm / 16,750V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.81	0	16750	0.000233	0.001326171	0	0
2.74	0.001	16750	0.000232	0.001293135	0.24884	8.28059E-05
2.67	0.002	16750	0.000231	0.001260098	0.49768	0.000162079
2.61	0.003	16750	0.000235	0.001231782	0.74652	0.000233611
2.55	0.004	16750	0.000237	0.001203465	0.99536	0.000301752
2.49	0.005	16750	0.000236	0.001175148	1.2442	0.000369876
2.43	0.006	16750	0.000236	0.001146831	1.49304	0.000433156
2.38	0.007	16750	0.000236	0.001123234	1.74188	0.00049495
2.36	0.008	16750	0.000234	0.001113795	1.99072	0.000565698
2.33	0.009	16750	0.00023	0.001099637	2.23956	0.000639248
2.31	0.01	16750	0.000231	0.001090198	2.4884	0.00070113
2.27	0.011	16750	0.000231	0.00107132	2.73724	0.000757888
2.23	0.012	16750	0.000233	0.001052442	2.98608	0.000805246
2.17	0.013	16750	0.00023	0.001024125	3.23492	0.000859951
2.14	0.014	16750	0.000233	0.001009967	3.48376	0.000901539
2.08	0.015	16750	0.000231	0.00098165	3.7326	0.000946981
2.03	0.016	16750	0.000228	0.000958052	3.98144	0.000998803
1.98	0.017	16750	0.000235	0.000934455	4.23028	0.001004257
1.95	0.018	16750	0.000236	0.000920297	4.47912	0.001042782
1.88	0.019	16750	0.000236	0.00088726	4.72796	0.001061202
1.85	0.02	16750	0.000237	0.000873102	4.9768	0.001094591
1.77	0.021	16750	0.000239	0.000835346	5.22564	0.001090419
1.73	0.022	16750	0.000238	0.000816468	5.47448	0.001121219
1.7	0.023	16750	0.00024	0.00080231	5.72332	0.001142258
1.62	0.024	16750	0.000236	0.000764554	5.97216	0.001155082
1.56	0.025	16750	0.000238	0.000736237	6.221	0.001148911
1.49	0.026	16750	0.000239	0.000703201	6.46984	0.001136476
1.37	0.027	16750	0.000237	0.000646567	6.71868	0.001094295
1.32	0.028	16750	0.000235	0.00062297	6.96752	0.001102714
1.27	0.029	16750	0.000238	0.000599373	7.21636	0.001084984
1.21	0.03	16750	0.000239	0.000571056	7.4652	0.001064896
1.08	0.031	16750	0.000236	0.000509703	7.71404	0.000994654
0.96	0.032	16750	0.000237	0.000453069	7.96288	0.000908807
0.82	0.033	16750	0.000243	0.000386997	8.21172	0.000780765
0.68	0.034	16750	0.000241	0.000320924	8.46056	0.000672619
0.57	0.035	16750	0.000241	0.00026901	8.7094	0.000580396
0.39	0.036	16750	0.000241	0.000184059	8.95824	0.000408459

0.25	0.037	16750	0.000243	0.000117987	9.20708	0.000266891
0.16	0.038	16750	0.000244	7.55115E-05	9.45592	0.000174708
0	0.039	16750	0.000246	0	9.70476	0

Conductive Graphite / Parabolic / 15mm / 18,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.92	0	18000	0.000286	0.001378085	0	0
2.84	0.001	18000	0.000289	0.001340329	0.24884	6.41153E-05
2.79	0.002	18000	0.000285	0.001316732	0.49768	0.000127741
2.73	0.003	18000	0.000283	0.001288415	0.74652	0.000188816
2.68	0.004	18000	0.000283	0.001264818	0.99536	0.000247144
2.66	0.005	18000	0.000285	0.001255379	1.2442	0.000304472
2.62	0.006	18000	0.000286	0.001236501	1.49304	0.000358614
2.6	0.007	18000	0.000286	0.001227062	1.74188	0.000415189
2.57	0.008	18000	0.000285	0.001212904	1.99072	0.000470673
2.52	0.009	18000	0.000283	0.001189306	2.23956	0.000522875
2.5	0.01	18000	0.000284	0.001179868	2.4884	0.000574331
2.46	0.011	18000	0.000284	0.00116099	2.73724	0.000621656
2.42	0.012	18000	0.000283	0.001142112	2.98608	0.000669501
2.38	0.013	18000	0.000285	0.001123234	3.23492	0.000708299
2.35	0.014	18000	0.000286	0.001109075	3.48376	0.000750535
2.3	0.015	18000	0.000288	0.001085478	3.7326	0.000781569
2.27	0.016	18000	0.000292	0.00107132	3.98144	0.000811529
2.24	0.017	18000	0.000288	0.001057161	4.23028	0.000862671
2.21	0.018	18000	0.000289	0.001043003	4.47912	0.000898065
2.16	0.019	18000	0.000291	0.001019406	4.72796	0.000920143
2.12	0.02	18000	0.000291	0.001000528	4.9768	0.000950635
2.09	0.021	18000	0.000291	0.000986369	5.22564	0.000984042
2.01	0.022	18000	0.000289	0.000948613	5.47448	0.000998302
1.93	0.023	18000	0.000293	0.000910858	5.72332	0.000988459
1.86	0.024	18000	0.00029	0.000877821	5.97216	0.001004308
1.81	0.025	18000	0.000291	0.000854224	6.221	0.001014534
1.75	0.026	18000	0.000291	0.000825907	6.46984	0.001020139
1.69	0.027	18000	0.000291	0.00079759	6.71868	0.001023054
1.63	0.028	18000	0.000291	0.000769274	6.96752	0.001023278
1.58	0.029	18000	0.000293	0.000745676	7.21636	0.001020301
1.52	0.03	18000	0.000294	0.000717359	7.4652	0.001011949
1.46	0.031	18000	0.000293	0.000689043	7.71404	0.001007831

1.39	0.032	18000	0.000298	0.000656006	7.96288	0.000973844
1.3	0.033	18000	0.000299	0.000613531	8.21172	0.00093611
1.21	0.034	18000	0.000299	0.000571056	8.46056	0.000897706
1.09	0.035	18000	0.000299	0.000514422	8.7094	0.000832462
0.98	0.036	18000	0.000301	0.000462508	8.95824	0.000764721
0.81	0.037	18000	0.000302	0.000382277	9.20708	0.000647472
0.74	0.038	18000	0.000301	0.000349241	9.45592	0.000609522
0.57	0.039	18000	0.0003	0.00026901	9.70476	0.000483458
0.43	0.04	18000	0.000299	0.000202937	9.9536	0.000375317
0.36	0.041	18000	0.000299	0.000169901	10.20244	0.000322074
0.25	0.042	18000	0.000303	0.000117987	10.45128	0.000226093
0.16	0.043	18000	0.000303	7.55115E-05	10.70012	0.000148145
0	0.044	18000	0.000305	0	10.94896	0

Conductive Graphite / Parabolic / 20mm / 17,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.34	0	17500	0.000162	0.001104356	0	0
2.27	0.001	17500	0.000163	0.00107132	0.24884	9.34574E-05
2.18	0.002	17500	0.000164	0.001028844	0.49768	0.00017841
2.14	0.003	17500	0.000165	0.001009967	0.74652	0.000261112
2.11	0.004	17500	0.000163	0.000995808	0.99536	0.00034748
2.06	0.005	17500	0.000164	0.000972211	1.2442	0.000421472
1.99	0.006	17500	0.000162	0.000939175	1.49304	0.000494612
1.93	0.007	17500	0.000161	0.000910858	1.74188	0.000563125
1.9	0.008	17500	0.000161	0.000896699	1.99072	0.000633568
1.84	0.009	17500	0.000162	0.000868382	2.23956	0.000685995
1.8	0.01	17500	0.000161	0.000849505	2.4884	0.000750278
1.76	0.011	17500	0.000163	0.000830627	2.73724	0.000797064
1.72	0.012	17500	0.000162	0.000811749	2.98608	0.000855008
1.68	0.013	17500	0.000163	0.000792871	3.23492	0.000899167
1.62	0.014	17500	0.000161	0.000764554	3.48376	0.00094535
1.59	0.015	17500	0.000163	0.000750396	3.7326	0.00098192
1.54	0.016	17500	0.000162	0.000726798	3.98144	0.001020707
1.49	0.017	17500	0.000163	0.000703201	4.23028	0.001042853
1.44	0.018	17500	0.000163	0.000679604	4.47912	0.001067143
1.35	0.019	17500	0.000163	0.000637128	4.72796	0.001056027
1.32	0.02	17500	0.000163	0.00062297	4.9768	0.001086905
1.27	0.021	17500	0.000163	0.000599373	5.22564	0.001098021

1.19	0.022	17500	0.000164	0.000561617	5.47448	0.001071275
1.11	0.023	17500	0.000163	0.000523861	5.72332	0.001051087
0.99	0.024	17500	0.000164	0.000467228	5.97216	0.00097225
0.91	0.025	17500	0.000165	0.000429472	6.221	0.000925279
0.88	0.026	17500	0.000164	0.000415313	6.46984	0.000936241
0.79	0.027	17500	0.000163	0.000372838	6.71868	0.00087817
0.71	0.028	17500	0.000165	0.000335082	6.96752	0.000808552
0.63	0.029	17500	0.000163	0.000297327	7.21636	0.000752188
0.52	0.03	17500	0.000164	0.000245412	7.4652	0.000638346
0.46	0.031	17500	0.000163	0.000217096	7.71404	0.000587094
0.31	0.032	17500	0.000166	0.000146304	7.96288	0.000401032
0.19	0.033	17500	0.000165	8.96699E-05	8.21172	0.000255011
0	0.034	17500	0.000166	0	8.46056	0

Conductive Graphite / Parabolic / 20mm / 19,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.71	0	19500	0.00022	0.001278976	0	0
2.63	0.001	19500	0.000219	0.001241221	0.24884	7.23253E-05
2.55	0.002	19500	0.000222	0.001203465	0.49768	0.000138355
2.5	0.003	19500	0.000222	0.001179868	0.74652	0.000203464
2.47	0.004	19500	0.00022	0.001165709	0.99536	0.000270466
2.41	0.005	19500	0.000219	0.001137392	1.2442	0.000331377
2.38	0.006	19500	0.000221	0.001123234	1.49304	0.000389148
2.34	0.007	19500	0.00022	0.001104356	1.74188	0.000448405
2.29	0.008	19500	0.000221	0.001080759	1.99072	0.000499243
2.25	0.009	19500	0.00022	0.001061881	2.23956	0.000554346
2.21	0.01	19500	0.000222	0.001043003	2.4884	0.00059954
2.18	0.011	19500	0.000221	0.001028844	2.73724	0.000653485
2.13	0.012	19500	0.000222	0.001005247	2.98608	0.000693405
2.09	0.013	19500	0.000221	0.000986369	3.23492	0.000740417
2.03	0.014	19500	0.00022	0.000958052	3.48376	0.000778001
1.99	0.015	19500	0.000222	0.000939175	3.7326	0.000809786
1.96	0.016	19500	0.000221	0.000925016	3.98144	0.000854599
1.93	0.017	19500	0.000222	0.000910858	4.23028	0.000890086
1.89	0.018	19500	0.000224	0.00089198	4.47912	0.000914671
1.84	0.019	19500	0.000222	0.000868382	4.72796	0.000948412
1.78	0.02	19500	0.000221	0.000840066	4.9768	0.000970145
1.75	0.021	19500	0.00022	0.000825907	5.22564	0.001006036

1.69	0.022	19500	0.000219	0.00079759	5.47448	0.001022455
1.66	0.023	19500	0.000221	0.000783432	5.72332	0.001040453
1.59	0.024	19500	0.000222	0.000750396	5.97216	0.001035224
1.51	0.025	19500	0.000219	0.00071264	6.221	0.00103813
1.47	0.026	19500	0.000222	0.000693762	6.46984	0.001036851
1.42	0.027	19500	0.000223	0.000670165	6.71868	0.001035443
1.37	0.028	19500	0.000223	0.000646567	6.96752	0.001035983
1.32	0.029	19500	0.00022	0.00062297	7.21636	0.00104792
1.24	0.03	19500	0.000219	0.000585214	7.4652	0.001023005
1.19	0.031	19500	0.000219	0.000561617	7.71404	0.00101448
1.12	0.032	19500	0.000219	0.000528581	7.96288	0.000985605
1.03	0.033	19500	0.000222	0.000486105	8.21172	0.000922098
0.97	0.034	19500	0.000224	0.000457789	8.46056	0.00088671
0.86	0.035	19500	0.000222	0.000405874	8.7094	0.000816568
0.76	0.036	19500	0.00022	0.00035868	8.95824	0.000748983
0.68	0.037	19500	0.000223	0.000320924	9.20708	0.000679492
0.51	0.038	19500	0.000224	0.000240693	9.45592	0.000521056
0.4	0.039	19500	0.000222	0.000188779	9.70476	0.000423205
0.33	0.04	19500	0.000223	0.000155743	9.9536	0.00035649
0.26	0.041	19500	0.000224	0.000122706	10.20244	0.000286608
0.11	0.042	19500	0.000226	5.19142E-05	10.45128	0.000123115
0	0.043	19500	0.000229	0	10.70012	0

Conductive Graphite / Parabolic / 20mm / 20,750V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.88	0	20750	0.000268	0.001359207	0	0
2.82	0.001	20750	0.000268	0.001330891	0.24884	5.95538E-05
2.78	0.002	20750	0.000268	0.001312013	0.49768	0.000117418
2.75	0.003	20750	0.000269	0.001297854	0.74652	0.000173579
2.69	0.004	20750	0.000265	0.001269537	0.99536	0.000229806
2.66	0.005	20750	0.000265	0.001255379	1.2442	0.000284054
2.63	0.006	20750	0.000264	0.001241221	1.49304	0.000338297
2.61	0.007	20750	0.000261	0.001231782	1.74188	0.000396181
2.57	0.008	20750	0.000264	0.001212904	1.99072	0.000440773
2.52	0.009	20750	0.000267	0.001189306	2.23956	0.000480759
2.48	0.01	20750	0.000268	0.001170429	2.4884	0.000523736
2.43	0.011	20750	0.000272	0.001146831	2.73724	0.000556193
2.38	0.012	20750	0.000274	0.001123234	2.98608	0.000589933

2.32	0.013	20750	0.000268	0.001094917	3.23492	0.00063693
2.28	0.014	20750	0.000271	0.001076039	3.48376	0.000666636
2.22	0.015	20750	0.000267	0.001047722	3.7326	0.000705876
2.2	0.016	20750	0.000265	0.001038283	3.98144	0.000751782
2.17	0.017	20750	0.000268	0.001024125	4.23028	0.000779057
2.13	0.018	20750	0.000269	0.001005247	4.47912	0.000806669
2.09	0.019	20750	0.00027	0.000986369	4.72796	0.000832399
2.06	0.02	20750	0.000269	0.000972211	4.9768	0.000866843
2.03	0.021	20750	0.000269	0.000958052	5.22564	0.00089693
2	0.022	20750	0.00027	0.000943894	5.47448	0.000922326
1.96	0.023	20750	0.000271	0.000925016	5.72332	0.000941477
1.93	0.024	20750	0.000269	0.000910858	5.97216	0.000974567
1.89	0.025	20750	0.000268	0.00089198	6.221	0.000997843
1.82	0.026	20750	0.00027	0.000858944	6.46984	0.000991919
1.77	0.027	20750	0.000269	0.000835346	6.71868	0.001005495
1.69	0.028	20750	0.000266	0.00079759	6.96752	0.001006835
1.61	0.029	20750	0.000271	0.000759835	7.21636	0.000975102
1.57	0.03	20750	0.00027	0.000740957	7.4652	0.000987308
1.53	0.031	20750	0.000272	0.000722079	7.71404	0.000986915
1.46	0.032	20750	0.000266	0.000689043	7.96288	0.000994069
1.4	0.033	20750	0.000265	0.000660726	8.21172	0.000986714
1.35	0.034	20750	0.000265	0.000637128	8.46056	0.000980307
1.23	0.035	20750	0.000268	0.000580495	8.7094	0.000909146
1.18	0.036	20750	0.000269	0.000556897	8.95824	0.000893774
1.11	0.037	20750	0.000268	0.000523861	9.20708	0.000867332
1.04	0.038	20750	0.000268	0.000490825	9.45592	0.000834598
0.96	0.039	20750	0.000269	0.000453069	9.70476	0.000787733
0.88	0.04	20750	0.000268	0.000415313	9.9536	0.000743367
0.81	0.041	20750	0.000271	0.000382277	10.20244	0.000693577
0.72	0.042	20750	0.000269	0.000339802	10.45128	0.000636246
0.64	0.043	20750	0.000271	0.000302046	10.70012	0.000574744
0.51	0.044	20750	0.000269	0.000240693	10.94896	0.000472135
0.44	0.045	20750	0.00027	0.000207657	11.1978	0.000415046
0.35	0.046	20750	0.000271	0.000165181	11.44664	0.000336242
0.19	0.047	20750	0.00027	8.96699E-05	11.69548	0.00018719
0	0.048	20750	0.000273	0	11.94432	0

Conductive Graphite / 4-Stage / 10mm / 8,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.39	0	8500	0.000272	0.000656006	0	0
1.32	0.001	8500	0.000272	0.00062297	0.24884	6.705E-05
1.26	0.002	8500	0.000272	0.000594653	0.49768	0.000128
1.13	0.003	8500	0.000272	0.0005333	0.74652	0.0001722
1.08	0.004	8500	0.000272	0.000509703	0.99536	0.00021944
1.01	0.005	8500	0.000273	0.000476666	1.2442	0.00025558
0.96	0.006	8500	0.000273	0.000453069	1.49304	0.00029151
0.93	0.007	8500	0.000272	0.000438911	1.74188	0.00033068
0.88	0.008	8500	0.000273	0.000415313	1.99072	0.00035629
0.82	0.009	8500	0.000273	0.000386997	2.23956	0.0003735
0.73	0.01	8500	0.000273	0.000344521	2.4884	0.00036945
0.65	0.011	8500	0.000274	0.000306766	2.73724	0.00036054
0.55	0.012	8500	0.000274	0.000259571	2.98608	0.0003328
0.46	0.013	8500	0.000274	0.000217096	3.23492	0.00030154
0.32	0.014	8500	0.000274	0.000151023	3.48376	0.0002259
0.27	0.015	8500	0.000274	0.000127426	3.7326	0.00020422
0.14	0.016	8500	0.000273	6.60726E-05	3.98144	0.00011337
0	0.017	8500	0.000273	0	4.23028	0

Conductive Graphite / 4-Stage / 10mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.74	0	10000	0.000539	0.000821188	0	0
1.67	0.001	10000	0.000541	0.000788151	0.24884	3.6252E-05
1.59	0.002	10000	0.00054	0.000750396	0.49768	6.9159E-05
1.52	0.003	10000	0.000543	0.000717359	0.74652	9.8623E-05
1.46	0.004	10000	0.000543	0.000689043	0.99536	0.00012631
1.33	0.005	10000	0.000546	0.00062769	1.2442	0.00014304
1.28	0.006	10000	0.000546	0.000604092	1.49304	0.00016519
1.22	0.007	10000	0.000547	0.000575775	1.74188	0.00018335
1.14	0.008	10000	0.000546	0.00053802	1.99072	0.00019616
1.07	0.009	10000	0.000547	0.000504983	2.23956	0.00020675
1.01	0.01	10000	0.000546	0.000476666	2.4884	0.00021724
0.94	0.011	10000	0.000547	0.00044363	2.73724	0.000222
0.89	0.012	10000	0.000549	0.000420033	2.98608	0.00022846

0.81	0.013	10000	0.00055	0.000382277	3.23492	0.00022484
0.77	0.014	10000	0.000549	0.000363399	3.48376	0.0002306
0.72	0.015	10000	0.000549	0.000339802	3.7326	0.00023103
0.67	0.016	10000	0.000549	0.000316204	3.98144	0.00022932
0.59	0.017	10000	0.00055	0.000278449	4.23028	0.00021417
0.51	0.018	10000	0.00055	0.000240693	4.47912	0.00019602
0.46	0.019	10000	0.000548	0.000217096	4.72796	0.0001873
0.38	0.02	10000	0.000551	0.00017934	4.9768	0.00016199
0.32	0.021	10000	0.000551	0.000151023	5.22564	0.00014323
0.25	0.022	10000	0.00055	0.000117987	5.47448	0.00011744
0.17	0.023	10000	0.00055	8.0231E-05	5.72332	8.3489E-05
0	0.024	10000	0.00055	0	5.97216	0

Conductive Graphite / 4-Stage / 10mm / 11,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.02	0	11500	0.000563	0.000953333	0	0
1.96	0.001	11500	0.000563	0.000925016	0.24884	3.5552E-05
1.9	0.002	11500	0.000563	0.000896699	0.49768	6.8927E-05
1.86	0.003	11500	0.000564	0.000877821	0.74652	0.00010103
1.83	0.004	11500	0.000565	0.000863663	0.99536	0.00013231
1.78	0.005	11500	0.000564	0.000840066	1.2442	0.00016115
1.73	0.006	11500	0.000564	0.000816468	1.49304	0.00018795
1.67	0.007	11500	0.000564	0.000788151	1.74188	0.00021167
1.61	0.008	11500	0.000565	0.000759835	1.99072	0.0002328
1.55	0.009	11500	0.000564	0.000731518	2.23956	0.00025259
1.48	0.01	11500	0.000564	0.000698482	2.4884	0.00026798
1.45	0.011	11500	0.000564	0.000684323	2.73724	0.0002888
1.39	0.012	11500	0.000564	0.000656006	2.98608	0.00030202
1.33	0.013	11500	0.000564	0.00062769	3.23492	0.00031306
1.27	0.014	11500	0.000565	0.000599373	3.48376	0.00032137
1.22	0.015	11500	0.000565	0.000575775	3.7326	0.00033076
1.18	0.016	11500	0.000565	0.000556897	3.98144	0.00034125
1.12	0.017	11500	0.000565	0.000528581	4.23028	0.00034414
1.06	0.018	11500	0.000565	0.000500264	4.47912	0.00034486
1.01	0.019	11500	0.000565	0.000476666	4.72796	0.00034685
0.94	0.02	11500	0.000565	0.00044363	4.9768	0.0003398
0.82	0.021	11500	0.000564	0.000386997	5.22564	0.0003118
0.74	0.022	11500	0.000564	0.000349241	5.47448	0.00029478

0.63	0.023	11500	0.000564	0.000297327	5.72332	0.00026236
0.56	0.024	11500	0.000564	0.00026429	5.97216	0.00024335
0.46	0.025	11500	0.000564	0.000217096	6.221	0.00020823
0.33	0.026	11500	0.000564	0.000155743	6.46984	0.00015535
0.28	0.027	11500	0.000564	0.000132145	6.71868	0.00013689
0.17	0.028	11500	0.000564	8.0231E-05	6.96752	8.6187E-05
0	0.029	11500	0.000564	0	7.21636	0

Conductive Graphite / 4-Stage / 15mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.27	0	10000	0.000227	0.000599373	0	0
1.22	0.001	10000	0.000227	0.000575775	0.24884	6.312E-05
1.18	0.002	10000	0.000227	0.000556897	0.49768	0.0001221
1.14	0.003	10000	0.000227	0.00053802	0.74652	0.0001769
1.09	0.004	10000	0.000227	0.000514422	0.99536	0.0002256
0.93	0.005	10000	0.000226	0.000438911	1.2442	0.0002416
0.85	0.006	10000	0.000227	0.000401155	1.49304	0.0002639
0.76	0.007	10000	0.000227	0.00035868	1.74188	0.0002752
0.67	0.008	10000	0.000227	0.000316204	1.99072	0.0002773
0.55	0.009	10000	0.000227	0.000259571	2.23956	0.0002561
0.42	0.01	10000	0.000227	0.000198218	2.4884	0.0002173
0.3	0.011	10000	0.000227	0.000141584	2.73724	0.0001707
0.21	0.012	10000	0.000227	9.91089E-05	2.98608	0.0001304
0.14	0.013	10000	0.000227	6.60726E-05	3.23492	9.416E-05
0	0.014	10000	0.000227	0	3.48376	0

Conductive Graphite / 4-Stage / 15mm / 11,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.56	0	11500	0.000338	0.000736237	0	0
1.51	0.001	11500	0.000339	0.00071264	0.24884	4.549E-05
1.44	0.002	11500	0.000338	0.000679604	0.49768	8.701E-05
1.36	0.003	11500	0.000339	0.000641848	0.74652	0.0001229
1.31	0.004	11500	0.000338	0.000618251	0.99536	0.0001583
1.24	0.005	11500	0.000338	0.000585214	1.2442	0.0001873
1.16	0.006	11500	0.000338	0.000547459	1.49304	0.0002103

1.09	0.007	11500	0.000338	0.000514422	1.74188	0.0002305
0.98	0.008	11500	0.000338	0.000462508	1.99072	0.0002369
0.92	0.009	11500	0.000339	0.000434191	2.23956	0.0002494
0.81	0.01	11500	0.00034	0.000382277	2.4884	0.0002433
0.72	0.011	11500	0.000339	0.000339802	2.73724	0.0002386
0.65	0.012	11500	0.000339	0.000306766	2.98608	0.000235
0.58	0.013	11500	0.000339	0.000273729	3.23492	0.0002271
0.43	0.014	11500	0.000341	0.000202937	3.48376	0.0001803
0.33	0.015	11500	0.000342	0.000155743	3.7326	0.0001478
0.24	0.016	11500	0.000342	0.000113267	3.98144	0.0001147
0.16	0.017	11500	0.000343	7.55115E-05	4.23028	8.098E-05
0	0.018	11500	0.000343	0	4.47912	0

Conductive Graphite / 4-Stage / 15mm / 13,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.79	0	13000	0.000481	0.000844785	0	0
1.74	0.001	13000	0.000481	0.000821188	0.24884	3.268E-05
1.69	0.002	13000	0.00048	0.00079759	0.49768	6.361E-05
1.62	0.003	13000	0.00048	0.000764554	0.74652	9.147E-05
1.58	0.004	13000	0.00048	0.000745676	0.99536	0.0001189
1.53	0.005	13000	0.000481	0.000722079	1.2442	0.0001437
1.46	0.006	13000	0.000481	0.000689043	1.49304	0.0001645
1.4	0.007	13000	0.000481	0.000660726	1.74188	0.0001841
1.34	0.008	13000	0.000482	0.000632409	1.99072	0.0002009
1.26	0.009	13000	0.000483	0.000594653	2.23956	0.0002121
1.21	0.01	13000	0.000483	0.000571056	2.4884	0.0002263
1.15	0.011	13000	0.000483	0.000542739	2.73724	0.0002366
1.09	0.012	13000	0.000483	0.000514422	2.98608	0.0002446
0.99	0.013	13000	0.000484	0.000467228	3.23492	0.0002402
0.92	0.014	13000	0.000483	0.000434191	3.48376	0.0002409
0.85	0.015	13000	0.000484	0.000401155	3.7326	0.000238
0.76	0.016	13000	0.000484	0.00035868	3.98144	0.000227
0.7	0.017	13000	0.000484	0.000330363	4.23028	0.0002221
0.63	0.018	13000	0.000484	0.000297327	4.47912	0.0002117
0.54	0.019	13000	0.000485	0.000254851	4.72796	0.0001911
0.47	0.02	13000	0.000484	0.000221815	4.9768	0.0001754
0.35	0.021	13000	0.000484	0.000165181	5.22564	0.0001372
0.22	0.022	13000	0.000484	0.000103828	5.47448	9.034E-05

0.16	0.023	13000	0.000485	7.55115E-05	5.72332	6.855E-05
0	0.024	13000	0.000485	0	5.97216	0

Conductive Graphite / 4-Stage / 20mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.01	0	10000	0.000139	0.00047667	0	0
0.95	0.001	10000	0.000139	0.00044835	0.24884	8.0264E-05
0.89	0.002	10000	0.000139	0.00042003	0.49768	0.00015039
0.77	0.003	10000	0.000139	0.0003634	0.74652	0.00019517
0.73	0.004	10000	0.000139	0.00034452	0.99536	0.00024671
0.62	0.005	10000	0.000139	0.00029261	1.2442	0.00026191
0.51	0.006	10000	0.00014	0.00024069	1.49304	0.00025669
0.44	0.007	10000	0.00014	0.00020766	1.74188	0.00025837
0.31	0.008	10000	0.00014	0.0001463	1.99072	0.00020804
0.19	0.009	10000	0.00014	8.967E-05	2.23956	0.00014344
0	0.01	10000	0.00014	0	2.4884	0

Conductive Graphite / 4-Stage / 20mm / 13,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.4	0	13000	0.000294	0.00066073	0	0
1.35	0.001	13000	0.000294	0.00063713	0.24884	4.1482E-05
1.28	0.002	13000	0.000295	0.00060409	0.49768	7.8395E-05
1.22	0.003	13000	0.000293	0.00057578	0.74652	0.00011285
1.16	0.004	13000	0.000294	0.00054746	0.99536	0.00014257
1.09	0.005	13000	0.000294	0.00051442	1.2442	0.00016746
1.01	0.006	13000	0.000294	0.00047667	1.49304	0.00018621
0.92	0.007	13000	0.000294	0.00043419	1.74188	0.00019788
0.84	0.008	13000	0.000295	0.00039644	1.99072	0.00020579
0.75	0.009	13000	0.000294	0.00035396	2.23956	0.00020741
0.63	0.01	13000	0.000295	0.00029733	2.4884	0.00019293
0.51	0.011	13000	0.000295	0.00024069	2.73724	0.0001718
0.45	0.012	13000	0.000295	0.00021238	2.98608	0.00016536
0.33	0.013	13000	0.000295	0.00015574	3.23492	0.00013137
0.19	0.014	13000	0.000295	8.967E-05	3.48376	8.1457E-05
0	0.015	13000	0.000295	0	3.7326	0

Conductive Graphite / 4-Stage / 20mm / 16,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.81	0	16000	0.000533	0.00085422	0	0
1.75	0.001	16000	0.000534	0.00082591	0.24884	2.4054E-05
1.69	0.002	16000	0.000535	0.00079759	0.49768	4.6372E-05
1.63	0.003	16000	0.000533	0.00076927	0.74652	6.734E-05
1.55	0.004	16000	0.000534	0.00073152	0.99536	8.522E-05
1.48	0.005	16000	0.000533	0.00069848	1.2442	0.00010191
1.43	0.006	16000	0.000535	0.00067488	1.49304	0.00011771
1.37	0.007	16000	0.000536	0.00064657	1.74188	0.00013132
1.31	0.008	16000	0.000536	0.00061825	1.99072	0.00014351
1.24	0.009	16000	0.000537	0.00058521	2.23956	0.00015254
1.16	0.01	16000	0.000538	0.00054746	2.4884	0.00015826
1.07	0.011	16000	0.000538	0.00050498	2.73724	0.00016058
0.98	0.012	16000	0.000537	0.00046251	2.98608	0.00016074
0.87	0.013	16000	0.000537	0.00041059	3.23492	0.00015459
0.73	0.014	16000	0.000539	0.00034452	3.48376	0.00013917
0.62	0.015	16000	0.000538	0.00029261	3.7326	0.00012688
0.51	0.016	16000	0.00054	0.00024069	3.98144	0.00011091
0.45	0.017	16000	0.000538	0.00021238	4.23028	0.00010437
0.37	0.018	16000	0.000538	0.00017462	4.47912	9.0863E-05
0.28	0.019	16000	0.00054	0.00013215	4.72796	7.2312E-05
0.12	0.02	16000	0.00054	5.6634E-05	4.9768	3.2622E-05
0	0.021	16000	0.00054	0	5.22564	0

Conductive Graphite / 6-Stage / 10mm / 8,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.41	0	8500	0.000489	0.000665445	0	0
1.36	0.001	8500	0.000489	0.000641848	0.24884	3.84259E-05
1.29	0.002	8500	0.000489	0.000608812	0.49768	7.28963E-05
1.18	0.003	8500	0.00049	0.000556897	0.74652	9.98163E-05
1.09	0.004	8500	0.00049	0.000514422	0.99536	0.000122938
0.97	0.005	8500	0.00049	0.000457789	1.2442	0.000136754
0.92	0.006	8500	0.00049	0.000434191	1.49304	0.000155646

0.84	0.007	8500	0.00049	0.000396435	1.74188	0.000165797
0.75	0.008	8500	0.000491	0.00035396	1.99072	0.000168836
0.63	0.009	8500	0.00049	0.000297327	2.23956	0.000159875
0.54	0.01	8500	0.000489	0.000254851	2.4884	0.000152574
0.46	0.011	8500	0.00049	0.000217096	2.73724	0.000142675
0.4	0.012	8500	0.00049	0.000188779	2.98608	0.000135344
0.35	0.013	8500	0.000491	0.000165181	3.23492	0.000128034
0.27	0.014	8500	0.000492	0.000127426	3.48376	0.00010615
0.19	0.015	8500	0.000491	8.96699E-05	3.7326	8.0197E-05
0.08	0.016	8500	0.000492	3.77558E-05	3.98144	3.59451E-05
0	0.017	8500	0.000492	0	4.23028	0

Conductive Graphite / 6-Stage / 10mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.76	0	10000	0.000785	0.000830627	0	0
1.71	0.001	10000	0.000786	0.000807029	0.24884	2.55498E-05
1.65	0.002	10000	0.000786	0.000778713	0.49768	4.93066E-05
1.58	0.003	10000	0.000786	0.000745676	0.74652	7.08222E-05
1.52	0.004	10000	0.000786	0.000717359	0.99536	9.08436E-05
1.44	0.005	10000	0.000786	0.000679604	1.2442	0.000107578
1.35	0.006	10000	0.000786	0.000637128	1.49304	0.000121025
1.29	0.007	10000	0.000784	0.000608812	1.74188	0.000135265
1.23	0.008	10000	0.000786	0.000580495	1.99072	0.000147023
1.17	0.009	10000	0.000786	0.000552178	2.23956	0.000157333
1.11	0.01	10000	0.000786	0.000523861	2.4884	0.000165849
1.02	0.011	10000	0.000785	0.000481386	2.73724	0.000167856
0.94	0.012	10000	0.000787	0.00044363	2.98608	0.000168325
0.89	0.013	10000	0.000786	0.000420033	3.23492	0.000172872
0.81	0.014	10000	0.000785	0.000382277	3.48376	0.000169651
0.73	0.015	10000	0.000784	0.000344521	3.7326	0.000164026
0.68	0.016	10000	0.000784	0.000320924	3.98144	0.000162977
0.6	0.017	10000	0.000785	0.000283168	4.23028	0.000152596
0.54	0.018	10000	0.000786	0.000254851	4.47912	0.00014523
0.47	0.019	10000	0.000785	0.000221815	4.72796	0.000133597
0.41	0.02	10000	0.000786	0.000193498	4.9768	0.000122519
0.33	0.021	10000	0.000785	0.000155743	5.22564	0.000103676
0.24	0.022	10000	0.000785	0.000113267	5.47448	7.8991E-05
0.18	0.023	10000	0.000785	8.49505E-05	5.72332	6.19361E-05

0	0.024	10000	0.000785	0	5.97216	0

Conductive Graphite / 6-Stage / 10mm / 11,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.02	0	11500	0.00106	0.000953333	0	0
1.97	0.001	11500	0.00106	0.000929736	0.24884	1.89791E-05
1.92	0.002	11500	0.00106	0.000906138	0.49768	3.69948E-05
1.88	0.003	11500	0.00107	0.00088726	0.74652	5.38283E-05
1.82	0.004	11500	0.00108	0.000858944	0.99536	6.88372E-05
1.77	0.005	11500	0.00106	0.000835346	1.2442	8.52615E-05
1.72	0.006	11500	0.00106	0.000811749	1.49304	9.94236E-05
1.65	0.007	11500	0.00107	0.000778713	1.74188	0.000110234
1.59	0.008	11500	0.00106	0.000750396	1.99072	0.000122545
1.53	0.009	11500	0.00106	0.000722079	2.23956	0.000132661
1.49	0.01	11500	0.00106	0.000703201	2.4884	0.000143548
1.46	0.011	11500	0.00107	0.000689043	2.73724	0.000153277
1.41	0.012	11500	0.00107	0.000665445	2.98608	0.000161485
1.35	0.013	11500	0.00106	0.000637128	3.23492	0.000169078
1.3	0.014	11500	0.00106	0.000613531	3.48376	0.00017534
1.24	0.015	11500	0.00106	0.000585214	3.7326	0.000179194
1.15	0.016	11500	0.00106	0.000542739	3.98144	0.000177267
1.09	0.017	11500	0.00106	0.000514422	4.23028	0.000178519
1.02	0.018	11500	0.00106	0.000481386	4.47912	0.000176881
0.96	0.019	11500	0.00108	0.000453069	4.72796	0.000172471
0.84	0.02	11500	0.00108	0.000396435	4.9768	0.000158855
0.79	0.021	11500	0.00106	0.000372838	5.22564	0.000159829
0.72	0.022	11500	0.00106	0.000339802	5.47448	0.000152604
0.64	0.023	11500	0.00107	0.000302046	5.72332	0.000140488
0.5	0.024	11500	0.00107	0.000235974	5.97216	0.000114528
0.43	0.025	11500	0.00106	0.000202937	6.221	0.000103566
0.31	0.026	11500	0.00106	0.000146304	6.46984	7.76506E-05
0.18	0.027	11500	0.00106	8.49505E-05	6.71868	4.68216E-05
0	0.028	11500	0.00106	0	6.96752	0

Conductive Graphite / 6-Stage / 15mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.26	0	10000	0.000387	0.000594653	0	0
1.21	0.001	10000	0.000388	0.000571056	0.24884	3.66241E-05
1.18	0.002	10000	0.000388	0.000556897	0.49768	7.14321E-05
1.11	0.003	10000	0.000388	0.000523861	0.74652	0.000100792
1.05	0.004	10000	0.000389	0.000495544	0.99536	0.000126798
0.97	0.005	10000	0.000389	0.000457789	1.2442	0.000146422
0.89	0.006	10000	0.000389	0.000420033	1.49304	0.000161215
0.74	0.007	10000	0.000389	0.000349241	1.74188	0.000156384
0.67	0.008	10000	0.000389	0.000316204	1.99072	0.000161819
0.6	0.009	10000	0.00039	0.000283168	2.23956	0.000162608
0.51	0.01	10000	0.00039	0.000240693	2.4884	0.000153574
0.42	0.011	10000	0.000389	0.000198218	2.73724	0.000139478
0.29	0.012	10000	0.00039	0.000136865	2.98608	0.000104792
0.18	0.013	10000	0.00039	8.49505E-05	3.23492	7.04636E-05
0	0.014	10000	0.00039	0	3.48376	0

Conductive Graphite / 6-Stage / 15mm / 11,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.55	0	11500	0.00058	0.000731518	0	0
1.5	0.001	11500	0.00058	0.000707921	0.24884	2.64106E-05
1.44	0.002	11500	0.00058	0.000679604	0.49768	5.07084E-05
1.38	0.003	11500	0.00058	0.000651287	0.74652	7.28934E-05
1.31	0.004	11500	0.000579	0.000618251	0.99536	9.24205E-05
1.26	0.005	11500	0.00058	0.000594653	1.2442	0.000110925
1.22	0.006	11500	0.00058	0.000575775	1.49304	0.000128884
1.15	0.007	11500	0.000581	0.000542739	1.74188	0.000141493
1.03	0.008	11500	0.00058	0.000486105	1.99072	0.000145082
0.94	0.009	11500	0.000581	0.00044363	2.23956	0.0001487
0.88	0.01	11500	0.000579	0.000415313	2.4884	0.00015521
0.81	0.011	11500	0.00058	0.000382277	2.73724	0.000156879
0.68	0.012	11500	0.00058	0.000320924	2.98608	0.000143674
0.59	0.013	11500	0.000581	0.000278449	3.23492	0.000134814
0.5	0.014	11500	0.000582	0.000235974	3.48376	0.000122826
0.39	0.015	11500	0.000583	0.000184059	3.7326	0.000102471

0.24	0.016	11500	0.000582	0.000113267	3.98144	6.73789E-05
0.13	0.017	11500	0.000583	6.13531E-05	4.23028	3.87114E-05
0	0.018	11500	0.000583	0	4.47912	0

Conductive Graphite / 6-Stage / 15mm / 13,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.78	0	13000	0.000825	0.000840066	0	0
1.72	0.001	13000	0.000824	0.000811749	0.24884	1.88569E-05
1.67	0.002	13000	0.000824	0.000788151	0.49768	3.66176E-05
1.61	0.003	13000	0.000823	0.000759835	0.74652	5.30173E-05
1.56	0.004	13000	0.000822	0.000736237	0.99536	6.85777E-05
1.52	0.005	13000	0.000822	0.000717359	1.2442	8.35241E-05
1.47	0.006	13000	0.000821	0.000693762	1.49304	9.705E-05
1.41	0.007	13000	0.000823	0.000665445	1.74188	0.00010834
1.33	0.008	13000	0.00082	0.00062769	1.99072	0.000117219
1.26	0.009	13000	0.000822	0.000594653	2.23956	0.000124627
1.19	0.01	13000	0.000822	0.000561617	2.4884	0.000130781
1.12	0.011	13000	0.000821	0.000528581	2.73724	0.000135562
1.07	0.012	13000	0.000822	0.000504983	2.98608	0.000141112
1.01	0.013	13000	0.000821	0.000476666	3.23492	0.000144475
0.93	0.014	13000	0.000822	0.000438911	3.48376	0.00014309
0.89	0.015	13000	0.000823	0.000420033	3.7326	0.000146538
0.82	0.016	13000	0.000824	0.000386997	3.98144	0.000143839
0.76	0.017	13000	0.000824	0.00035868	4.23028	0.000141646
0.64	0.018	13000	0.000825	0.000302046	4.47912	0.000126145
0.55	0.019	13000	0.000823	0.000259571	4.72796	0.000114706
0.45	0.02	13000	0.000823	0.000212376	4.9768	9.87899E-05
0.34	0.021	13000	0.000823	0.000160462	5.22564	7.83734E-05
0.22	0.022	13000	0.000824	0.000103828	5.47448	5.30626E-05
0.13	0.023	13000	0.000824	6.13531E-05	5.72332	3.27804E-05
0	0.024	13000	0.000824	0	5.97216	0

Conductive Graphite / 6-Stage / 20mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.01	0	10000	0.000222	0.000476666	0	0

0.98	0.001	10000	0.000222	0.000462508	0.24884	5.18426E-05
0.92	0.002	10000	0.000222	0.000434191	0.49768	9.73371E-05
0.84	0.003	10000	0.000222	0.000396435	0.74652	0.000133309
0.72	0.004	10000	0.000222	0.000339802	0.99536	0.000152354
0.61	0.005	10000	0.000222	0.000287888	1.2442	0.000161347
0.53	0.006	10000	0.000222	0.000250132	1.49304	0.000168224
0.42	0.007	10000	0.000222	0.000198218	1.74188	0.000155528
0.31	0.008	10000	0.000223	0.000146304	1.99072	0.000130605
0.22	0.009	10000	0.000223	0.000103828	2.23956	0.000104273
0.13	0.01	10000	0.000223	6.13531E-05	2.4884	6.84624E-05
0	0.011	10000	0.000223	0	2.73724	0

Conductive Graphite / 6-Stage / 20mm / 13,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.42	0	13000	0.000468	0.000670165	0	0
1.38	0.001	13000	0.000468	0.000651287	0.24884	2.66381E-05
1.34	0.002	13000	0.000468	0.000632409	0.49768	5.1732E-05
1.27	0.003	13000	0.000468	0.000599373	0.74652	7.35443E-05
1.21	0.004	13000	0.000469	0.000571056	0.99536	9.32272E-05
1.13	0.005	13000	0.000469	0.0005333	1.2442	0.000108829
1.09	0.006	13000	0.00047	0.000514422	1.49304	0.000125704
0.93	0.007	13000	0.00047	0.000438911	1.74188	0.000125128
0.87	0.008	13000	0.00047	0.000410594	1.99072	0.000133777
0.82	0.009	13000	0.00047	0.000386997	2.23956	0.00014185
0.75	0.01	13000	0.000469	0.00035396	2.4884	0.000144464
0.71	0.011	13000	0.00047	0.000335082	2.73724	0.000150115
0.59	0.012	13000	0.00047	0.000278449	2.98608	0.000136083
0.44	0.013	13000	0.00047	0.000207657	3.23492	0.000109943
0.31	0.014	13000	0.00047	0.000146304	3.48376	8.34184E-05
0.22	0.015	13000	0.00047	0.000103828	3.7326	6.34287E-05
0.13	0.016	13000	0.000469	6.13531E-05	3.98144	4.00646E-05
0	0.017	13000	0.000469	0	4.23028	0

Conductive Graphite / 6-Stage / 20mm / 16,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.8	0	16000	0.000978	0.000849505	0	0
1.77	0.001	16000	0.000978	0.000835346	0.24884	1.3284E-05
1.74	0.002	16000	0.000978	0.000821188	0.49768	2.61176E-05
1.69	0.003	16000	0.000978	0.00079759	0.74652	3.80507E-05
1.63	0.004	16000	0.000979	0.000769274	0.99536	4.88831E-05
1.57	0.005	16000	0.000978	0.000740957	1.2442	5.89148E-05
1.51	0.006	16000	0.000978	0.00071264	1.49304	6.79959E-05
1.44	0.007	16000	0.000977	0.000679604	1.74188	7.57285E-05
1.36	0.008	16000	0.000977	0.000641848	1.99072	8.17387E-05
1.32	0.009	16000	0.000976	0.00062297	2.23956	8.93429E-05
1.26	0.01	16000	0.000976	0.000594653	2.4884	9.47576E-05
1.21	0.011	16000	0.000974	0.000571056	2.73724	0.000100303
1.17	0.012	16000	0.000973	0.000552178	2.98608	0.000105913
1.09	0.013	16000	0.000974	0.000514422	3.23492	0.000106784
0.97	0.014	16000	0.000972	0.000457789	3.48376	0.000102548
0.86	0.015	16000	0.000972	0.000405874	3.7326	9.7413E-05
0.69	0.016	16000	0.000973	0.000325643	3.98144	8.32817E-05
0.58	0.017	16000	0.000974	0.000273729	4.23028	7.43039E-05
0.51	0.018	16000	0.000976	0.000240693	4.47912	6.90377E-05
0.42	0.019	16000	0.000976	0.000198218	4.72796	6.00132E-05
0.3	0.02	16000	0.000976	0.000141584	4.9768	4.51227E-05
0.22	0.021	16000	0.000976	0.000103828	5.22564	3.47445E-05
0.13	0.022	16000	0.000976	6.13531E-05	5.47448	2.15085E-05
0	0.023	16000	0.000976	0	5.72332	0

Conductive Graphite / 8-Stage / 10mm / 8,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.42	0	8500	0.000695	0.000670165	0	0
1.37	0.001	8500	0.000694	0.000646567	0.24884	2.72744E-05
1.31	0.002	8500	0.000695	0.000618251	0.49768	5.20848E-05
1.25	0.003	8500	0.000694	0.000589934	0.74652	7.46563E-05
1.2	0.004	8500	0.000693	0.000566336	0.99536	9.56979E-05
1.14	0.005	8500	0.000693	0.00053802	1.2442	0.000113641
1.05	0.006	8500	0.000693	0.000495544	1.49304	0.000125604

0.99	0.007	8500	0.000692	0.000467228	1.74188	0.000138364
0.91	0.008	8500	0.000693	0.000429472	1.99072	0.000145142
0.84	0.009	8500	0.000693	0.000396435	2.23956	0.000150724
0.72	0.01	8500	0.000693	0.000339802	2.4884	0.000143547
0.66	0.011	8500	0.000693	0.000311485	2.73724	0.000144743
0.57	0.012	8500	0.000693	0.00026901	2.98608	0.00013637
0.43	0.013	8500	0.000693	0.000202937	3.23492	0.000111448
0.35	0.014	8500	0.000694	0.000165181	3.48376	9.75509E-05
0.23	0.015	8500	0.000694	0.000108548	3.7326	6.86838E-05
0.11	0.016	8500	0.000695	5.19142E-05	3.98144	3.49883E-05
0	0.017	8500	0.000695	0	4.23028	0

Conductive Graphite / 8-Stage / 10mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.76	0	10000	0.00111	0.000830627	0	0
1.72	0.001	10000	0.00111	0.000811749	0.24884	1.81978E-05
1.67	0.002	10000	0.00111	0.000788151	0.49768	3.53376E-05
1.61	0.003	10000	0.00111	0.000759835	0.74652	5.1102E-05
1.55	0.004	10000	0.00111	0.000731518	0.99536	6.55967E-05
1.51	0.005	10000	0.00111	0.00071264	1.2442	7.98799E-05
1.46	0.006	10000	0.00111	0.000689043	1.49304	9.26818E-05
1.39	0.007	10000	0.00111	0.000656006	1.74188	0.000102945
1.3	0.008	10000	0.00111	0.000613531	1.99072	0.000110033
1.25	0.009	10000	0.00111	0.000589934	2.23956	0.000119026
1.21	0.01	10000	0.00111	0.000571056	2.4884	0.000128019
1.17	0.011	10000	0.00111	0.000552178	2.73724	0.000136166
1.12	0.012	10000	0.00111	0.000528581	2.98608	0.000142197
1.05	0.013	10000	0.00111	0.000495544	3.23492	0.000144419
0.99	0.014	10000	0.00111	0.000467228	3.48376	0.00014664
0.92	0.015	10000	0.00111	0.000434191	3.7326	0.000146006
0.87	0.016	10000	0.00111	0.000410594	3.98144	0.000147275
0.73	0.017	10000	0.00111	0.000344521	4.23028	0.000131299
0.62	0.018	10000	0.00111	0.000292607	4.47912	0.000118074
0.51	0.019	10000	0.00111	0.000240693	4.72796	0.000102521
0.44	0.02	10000	0.00111	0.000207657	4.9768	9.3105E-05
0.32	0.021	10000	0.00111	0.000151023	5.22564	7.10984E-05
0.19	0.022	10000	0.00111	8.96699E-05	5.47448	4.42249E-05
0	0.023	10000	0.00111	0	5.72332	0

Conductive Graphite / 8-Stage / 10mm / 11,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
2.03	0	11500	0.00165	0.000958052	0	0
1.95	0.001	11500	0.00163	0.000920297	0.24884	1.22169E-05
1.91	0.002	11500	0.00162	0.000901419	0.49768	2.40804E-05
1.86	0.003	11500	0.0016	0.000877821	0.74652	3.56147E-05
1.82	0.004	11500	0.0016	0.000858944	0.99536	4.64651E-05
1.79	0.005	11500	0.0016	0.000844785	1.2442	5.7124E-05
1.73	0.006	11500	0.0016	0.000816468	1.49304	6.62511E-05
1.68	0.007	11500	0.0016	0.000792871	1.74188	7.5059E-05
1.64	0.008	11500	0.00161	0.000773993	1.99072	8.32192E-05
1.6	0.009	11500	0.00161	0.000755115	2.23956	9.13381E-05
1.56	0.01	11500	0.00161	0.000736237	2.4884	9.89497E-05
1.52	0.011	11500	0.0016	0.000717359	2.73724	0.000106717
1.47	0.012	11500	0.00161	0.000693762	2.98608	0.000111889
1.38	0.013	11500	0.0016	0.000651287	3.23492	0.000114503
1.31	0.014	11500	0.0016	0.000618251	3.48376	0.000117056
1.26	0.015	11500	0.00161	0.000594653	3.7326	0.000119881
1.18	0.016	11500	0.00161	0.000556897	3.98144	0.000119754
1.12	0.017	11500	0.00162	0.000528581	4.23028	0.000120024
1.04	0.018	11500	0.00162	0.000490825	4.47912	0.000118007
0.98	0.019	11500	0.00162	0.000462508	4.72796	0.000117376
0.87	0.02	11500	0.00163	0.000410594	4.9768	0.000109013
0.81	0.021	11500	0.00163	0.000382277	5.22564	0.000106569
0.75	0.022	11500	0.00165	0.00035396	5.47448	0.000102121
0.64	0.023	11500	0.00165	0.000302046	5.72332	9.11044E-05
0.53	0.024	11500	0.00165	0.000250132	5.97216	7.87261E-05
0.41	0.025	11500	0.00165	0.000193498	6.221	6.34389E-05
0.34	0.026	11500	0.00165	0.000160462	6.46984	5.47122E-05
0.22	0.027	11500	0.00167	0.000103828	6.71868	3.63233E-05
0.1	0.028	11500	0.00167	4.71947E-05	6.96752	1.71221E-05
0	0.029	11500	0.00167	0	7.21636	0

Conductive Graphite / 8-Stage / 15mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.28	0	10000	0.000527	0.000604092	0	0
1.23	0.001	10000	0.000527	0.000580495	0.24884	2.74099E-05
1.19	0.002	10000	0.000527	0.000561617	0.49768	5.30371E-05
1.11	0.003	10000	0.000527	0.000523861	0.74652	7.42074E-05
1.05	0.004	10000	0.000527	0.000495544	0.99536	9.35949E-05
0.97	0.005	10000	0.000527	0.000457789	1.2442	0.00010808
0.91	0.006	10000	0.000527	0.000429472	1.49304	0.000121673
0.8	0.007	10000	0.000528	0.000377558	1.74188	0.000124557
0.71	0.008	10000	0.000527	0.000335082	1.99072	0.000126576
0.66	0.009	10000	0.000528	0.000311485	2.23956	0.000132119
0.52	0.01	10000	0.000528	0.000245412	2.4884	0.00011566
0.39	0.011	10000	0.000528	0.000184059	2.73724	9.54194E-05
0.21	0.012	10000	0.000529	9.91089E-05	2.98608	5.59446E-05
0.09	0.013	10000	0.000529	4.24752E-05	3.23492	2.59743E-05
0	0.014	10000	0.000529	0	3.48376	0

Conductive Graphite / 8-Stage / 15mm / 11,500V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.56	0	11500	0.000781	0.000736237	0	0
1.51	0.001	11500	0.000782	0.00071264	0.24884	1.9719E-05
1.45	0.002	11500	0.000782	0.000684323	0.49768	3.7871E-05
1.38	0.003	11500	0.000783	0.000651287	0.74652	5.39951E-05
1.33	0.004	11500	0.000783	0.00062769	0.99536	6.9385E-05
1.25	0.005	11500	0.000784	0.000589934	1.2442	8.14103E-05
1.17	0.006	11500	0.000785	0.000552178	1.49304	9.13236E-05
1.08	0.007	11500	0.000784	0.000509703	1.74188	9.84739E-05
1.01	0.008	11500	0.000785	0.000476666	1.99072	0.000105113
0.94	0.009	11500	0.000785	0.00044363	2.23956	0.000110057
0.83	0.01	11500	0.000783	0.000391716	2.4884	0.000108251
0.76	0.011	11500	0.000784	0.00035868	2.73724	0.000108894
0.63	0.012	11500	0.000784	0.000297327	2.98608	9.84739E-05
0.57	0.013	11500	0.000784	0.00026901	3.23492	9.65201E-05
0.42	0.014	11500	0.000784	0.000198218	3.48376	7.65908E-05
0.35	0.015	11500	0.000784	0.000165181	3.7326	6.83847E-05

0.22	0.016	11500	0.000785	0.000103828	3.98144	4.57919E-05
0.13	0.017	11500	0.000785	6.13531E-05	4.23028	2.875E-05
0	0.018	11500	0.000784	0	4.47912	0

Conductive Graphite / 8-Stage / 15mm / 13,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.77	0	13000	0.00114	0.000835346	0	0
1.72	0.001	13000	0.00113	0.000811749	0.24884	1.37506E-05
1.67	0.002	13000	0.00113	0.000788151	0.49768	2.67016E-05
1.63	0.003	13000	0.00112	0.000769274	0.74652	3.94422E-05
1.55	0.004	13000	0.00111	0.000731518	0.99536	5.0459E-05
1.47	0.005	13000	0.00111	0.000693762	1.2442	5.98184E-05
1.42	0.006	13000	0.00111	0.000670165	1.49304	6.93405E-05
1.36	0.007	13000	0.0011	0.000641848	1.74188	7.81834E-05
1.3	0.008	13000	0.0011	0.000613531	1.99072	8.54104E-05
1.26	0.009	13000	0.0011	0.000594653	2.23956	9.31302E-05
1.21	0.01	13000	0.0011	0.000571056	2.4884	9.93717E-05
1.17	0.011	13000	0.0011	0.000552178	2.73724	0.000105695
1.12	0.012	13000	0.0011	0.000528581	2.98608	0.000110377
1.08	0.013	13000	0.0011	0.000509703	3.23492	0.000115304
1.03	0.014	13000	0.0011	0.000486105	3.48376	0.000118425
0.95	0.015	13000	0.0011	0.00044835	3.7326	0.000117029
0.9	0.016	13000	0.0011	0.000424752	3.98144	0.000118261
0.79	0.017	13000	0.0011	0.000372838	4.23028	0.000110294
0.68	0.018	13000	0.0011	0.000320924	4.47912	0.000100521
0.53	0.019	13000	0.0011	0.000250132	4.72796	8.27003E-05
0.44	0.02	13000	0.0011	0.000207657	4.9768	7.22703E-05
0.37	0.021	13000	0.0011	0.00017462	5.22564	6.38114E-05
0.22	0.022	13000	0.0011	0.000103828	5.47448	3.97487E-05
0.09	0.023	13000	0.0011	4.24752E-05	5.72332	1.7E-05
0	0.024	13000	0.0011	0	5.97216	0

Conductive Graphite / 8-Stage / 20mm / 10,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
0.99	0	10000	0.000319	0.000467228	0	0

0.92	0.001	10000	0.000318	0.000434191	0.24884	3.39761E-05
0.86	0.002	10000	0.000318	0.000405874	0.49768	6.35206E-05
0.81	0.003	10000	0.000318	0.000382277	0.74652	8.97413E-05
0.69	0.004	10000	0.000318	0.000325643	0.99536	0.000101928
0.53	0.005	10000	0.000319	0.000250132	1.2442	9.75593E-05
0.39	0.006	10000	0.000319	0.000184059	1.49304	8.61467E-05
0.26	0.007	10000	0.000319	0.000122706	1.74188	6.7003E-05
0.18	0.008	10000	0.000319	8.49505E-05	1.99072	5.30133E-05
0	0.009	10000	0.000319	0	2.23956	0

Conductive Graphite / 8-Stage / 20mm / 13,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.39	0	13000	0.000672	0.000656006	0	0
1.32	0.001	13000	0.000672	0.00062297	0.24884	1.77449E-05
1.27	0.002	13000	0.000674	0.000599373	0.49768	3.40443E-05
1.22	0.003	13000	0.000673	0.000575775	0.74652	4.91288E-05
1.15	0.004	13000	0.000674	0.000542739	0.99536	6.1655E-05
1.06	0.005	13000	0.000675	0.000500264	1.2442	7.0932E-05
0.96	0.006	13000	0.000675	0.000453069	1.49304	7.70884E-05
0.92	0.007	13000	0.000674	0.000434191	1.74188	8.63169E-05
0.81	0.008	13000	0.000674	0.000382277	1.99072	8.68531E-05
0.74	0.009	13000	0.000674	0.000349241	2.23956	8.92657E-05
0.65	0.01	13000	0.000675	0.000306766	2.4884	8.69921E-05
0.52	0.011	13000	0.000676	0.000245412	2.73724	7.64398E-05
0.44	0.012	13000	0.000675	0.000207657	2.98608	7.06643E-05
0.31	0.013	13000	0.000675	0.000146304	3.23492	5.39351E-05
0.16	0.014	13000	0.000677	7.55115E-05	3.48376	2.98902E-05
0	0.015	13000	0.000677	0	3.7326	0

Conductive Graphite / 8-Stage / 20mm / 16,000V						
Flow Rate	Pressure	Voltage	Current	Flow Rate	Pressure	Efficiency
CFM	inH2O	V	A	m3/s	N/m2	η
1.81	0	16000	0.00122	0.000854224	0	0
1.77	0.001	16000	0.00122	0.000835346	0.24884	1.0649E-05
1.72	0.002	16000	0.00121	0.000811749	0.49768	2.08673E-05
1.66	0.003	16000	0.00121	0.000783432	0.74652	3.02091E-05

1.62	0.004	16000	0.00121	0.000764554	0.99536	3.93082E-05
1.55	0.005	16000	0.00121	0.000731518	1.2442	4.70121E-05
1.49	0.006	16000	0.00121	0.000703201	1.49304	5.42307E-05
1.43	0.007	16000	0.00121	0.000674884	1.74188	6.07215E-05
1.39	0.008	16000	0.00121	0.000656006	1.99072	6.74548E-05
1.29	0.009	16000	0.00121	0.000608812	2.23956	7.04272E-05
1.24	0.01	16000	0.00121	0.000585214	2.4884	7.52194E-05
1.16	0.011	16000	0.00121	0.000547459	2.73724	7.74032E-05
1.11	0.012	16000	0.00121	0.000523861	2.98608	8.08002E-05
1.02	0.013	16000	0.00121	0.000481386	3.23492	8.04362E-05
0.93	0.014	16000	0.00121	0.000438911	3.48376	7.89803E-05
0.86	0.015	16000	0.00121	0.000405874	3.7326	7.82524E-05
0.77	0.016	16000	0.00121	0.000363399	3.98144	7.47341E-05
0.65	0.017	16000	0.00121	0.000306766	4.23028	6.70302E-05
0.53	0.018	16000	0.00121	0.000250132	4.47912	5.78704E-05
0.45	0.019	16000	0.00121	0.000212376	4.72796	5.1865E-05
0.33	0.02	16000	0.00121	0.000155743	4.9768	4.00361E-05
0.24	0.021	16000	0.00121	0.000113267	5.22564	3.0573E-05
0.13	0.022	16000	0.00121	6.13531E-05	5.47448	1.7349E-05
0	0.023	16000	0.00121	0	5.72332	0

APPENDIX B

The following graphs show the pressure versus volumetric airflow, and pressure versus efficiency curves for each of the ionic air moving devices tested.

Figure A 1

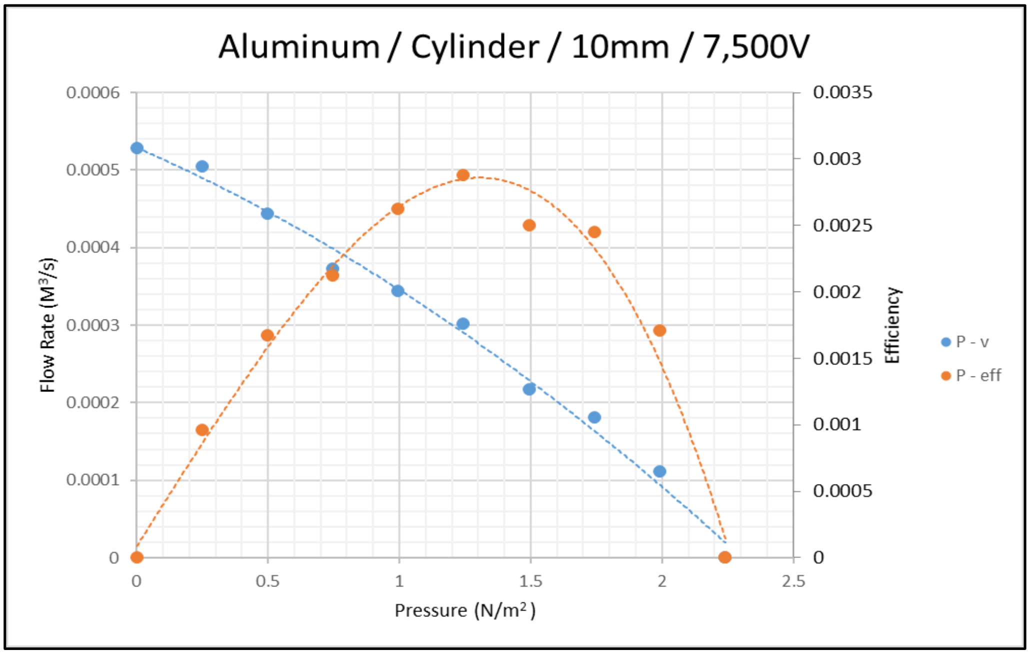


Figure A 2

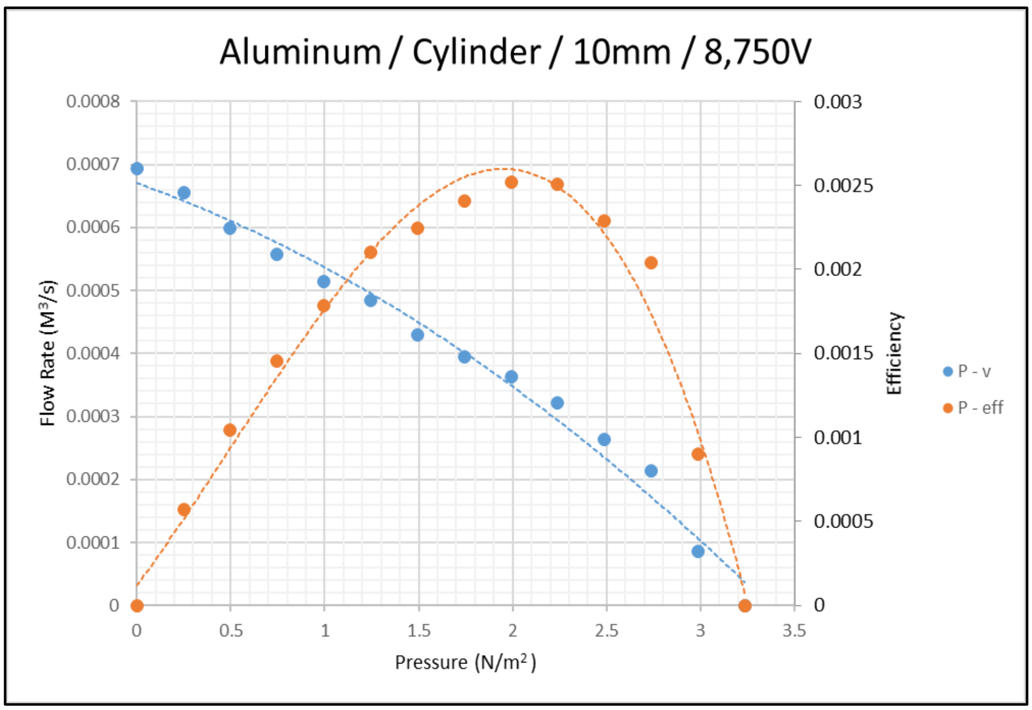


Figure A 3

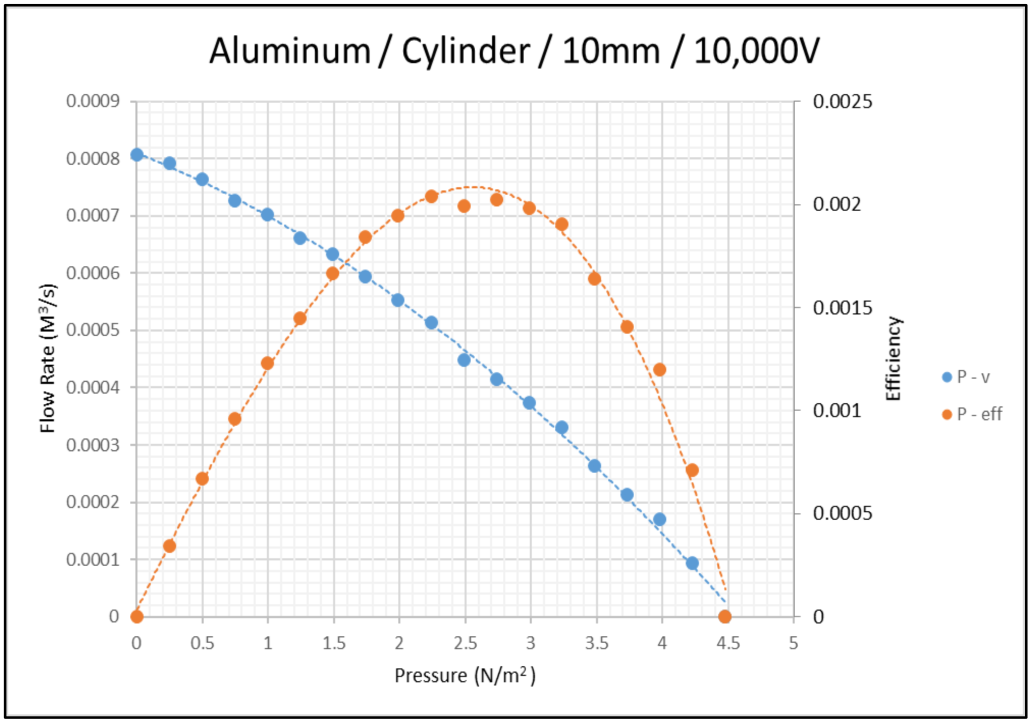


Figure A 4

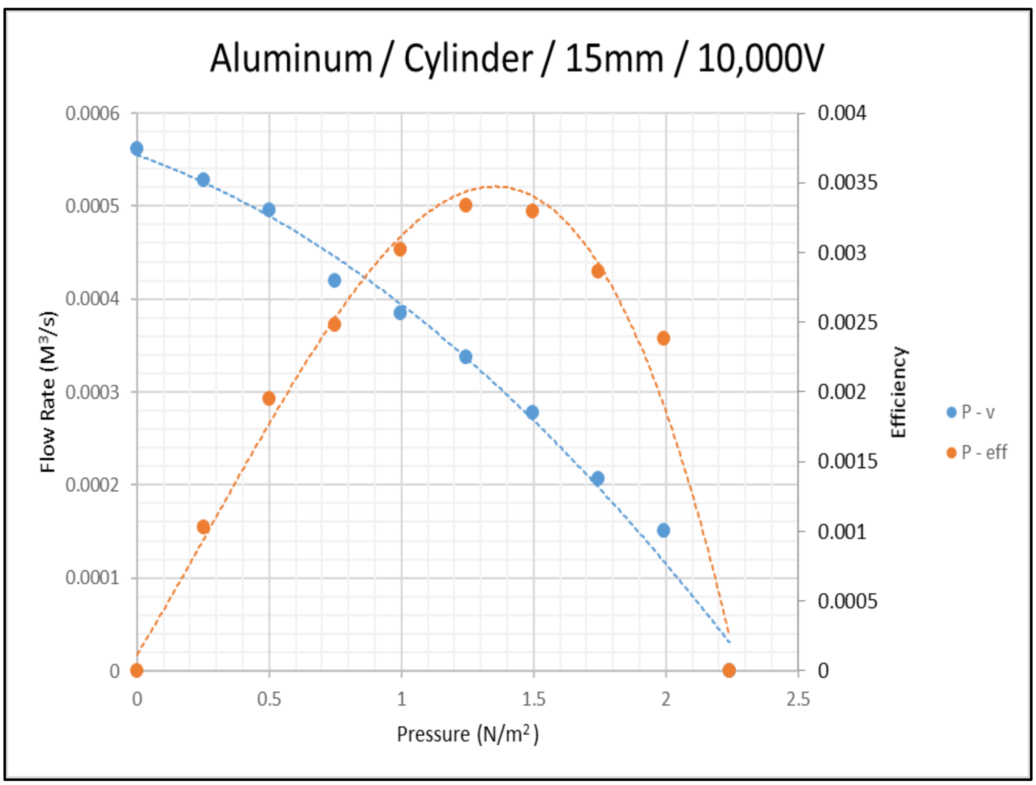


Figure A 5

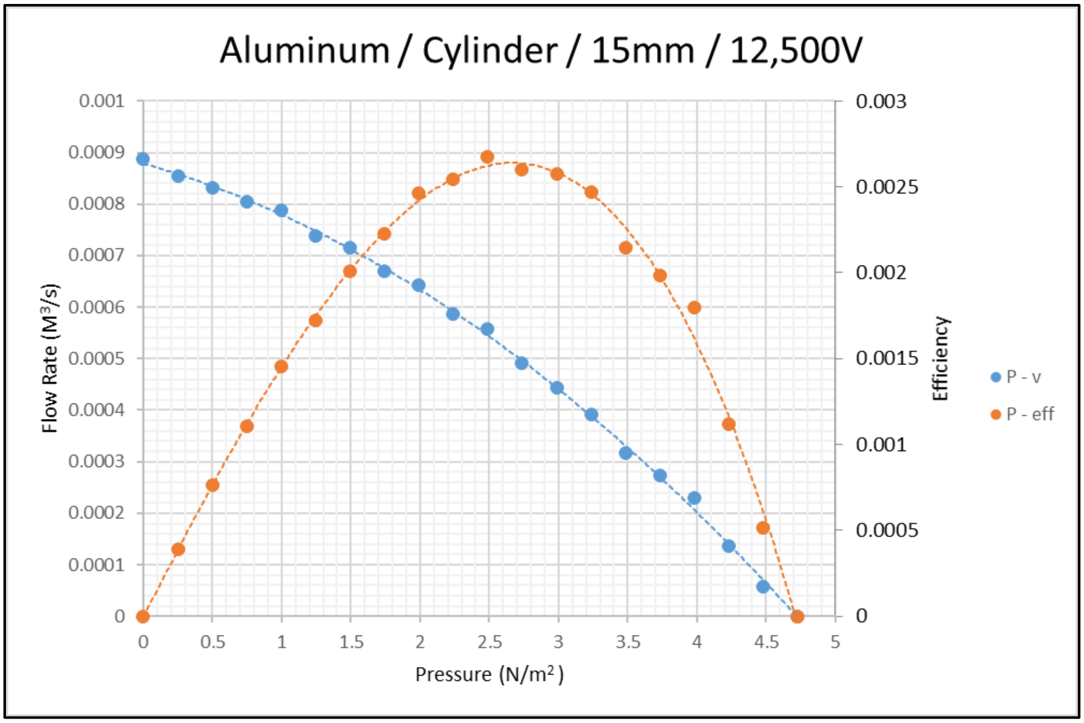


Figure A 6

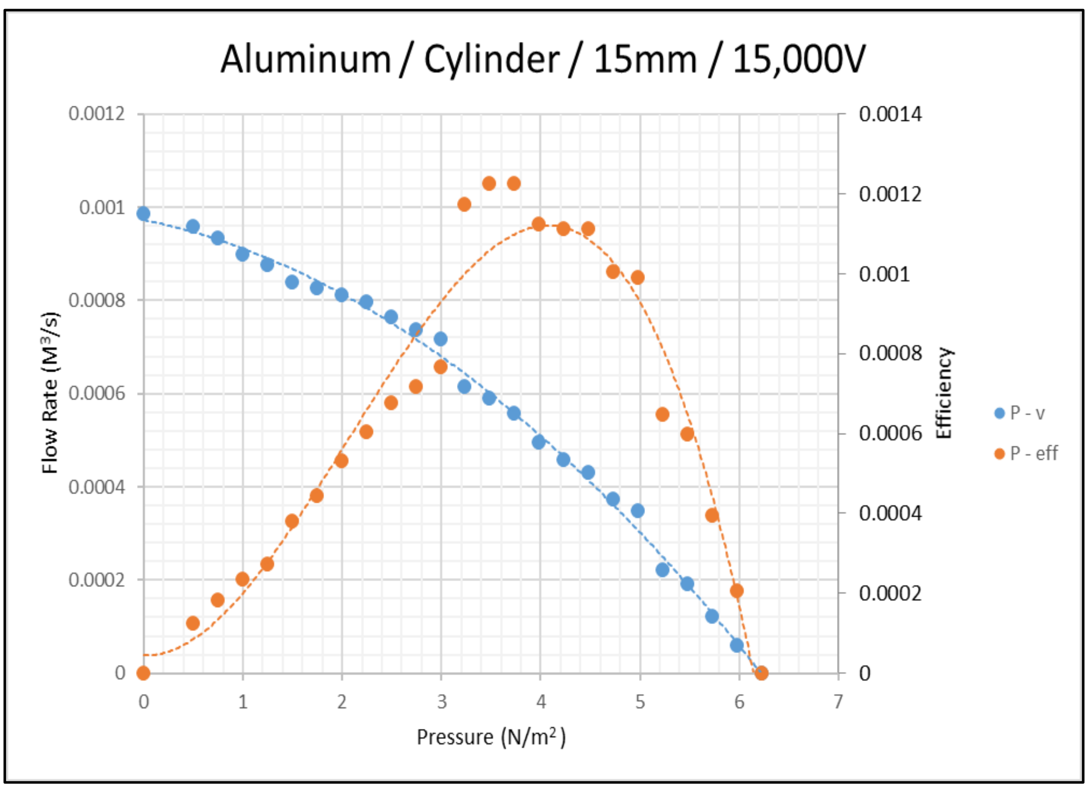


Figure A 7

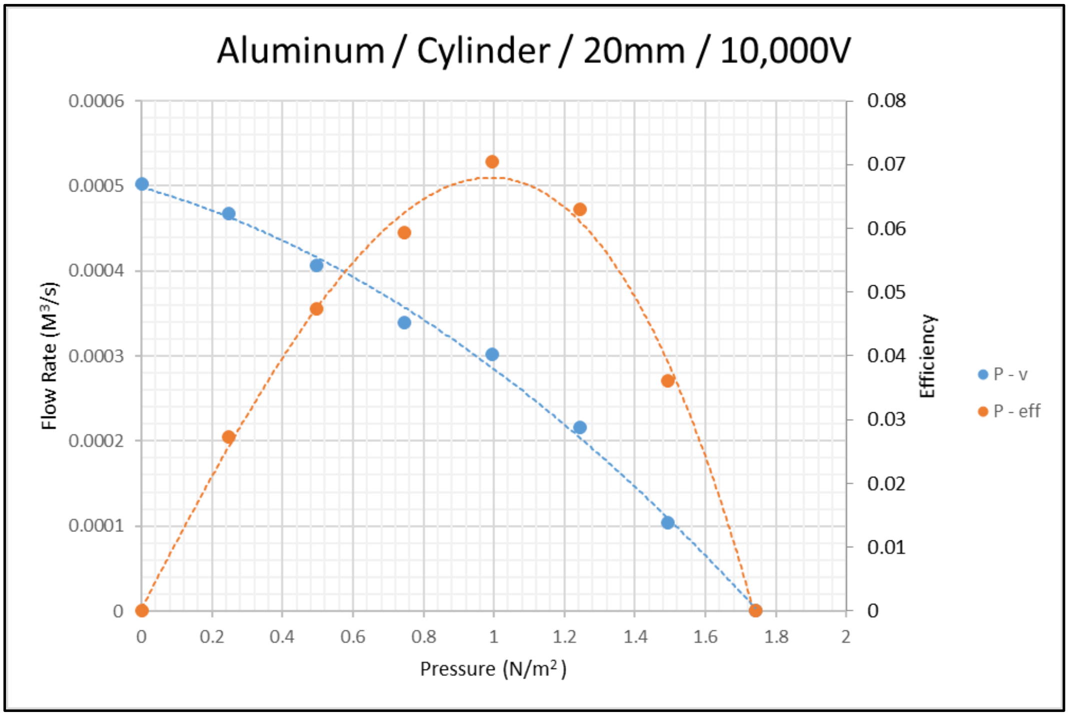


Figure A 8

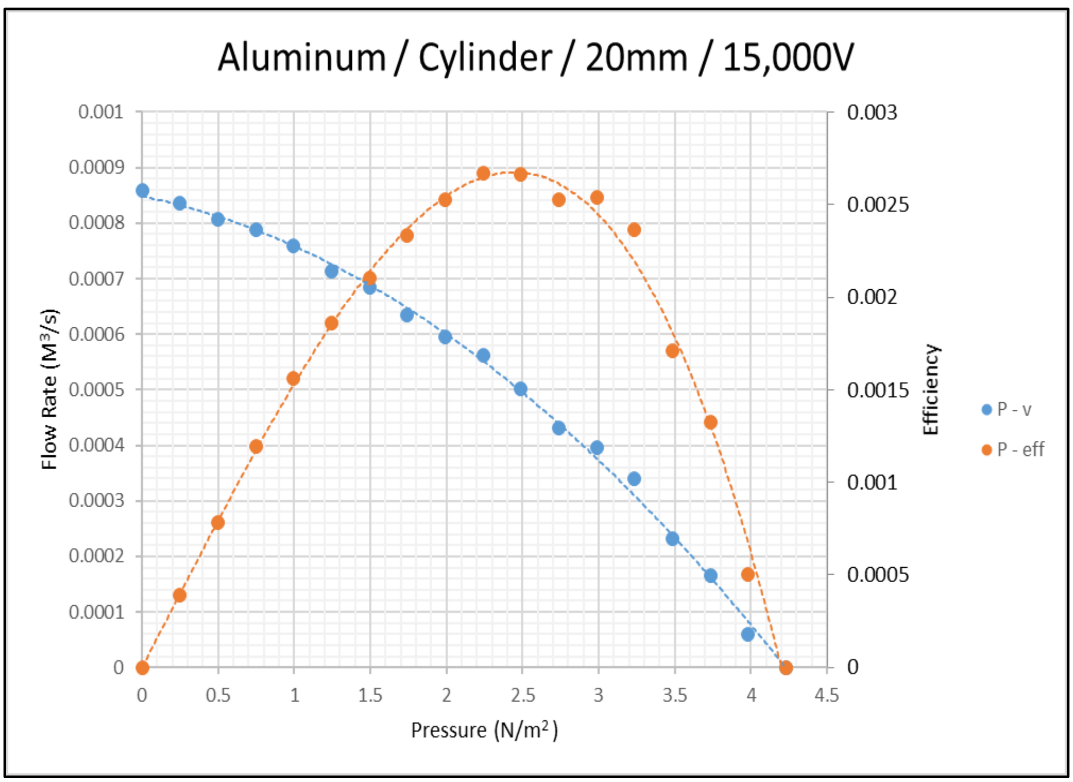


Figure A 9

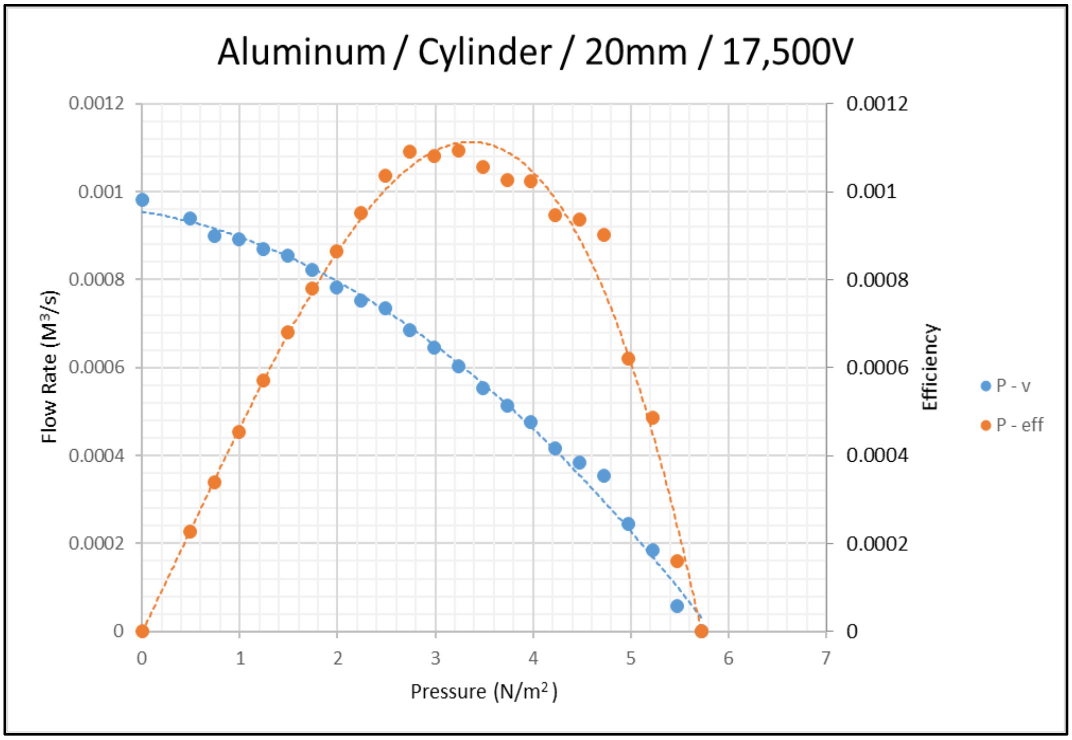


Figure A 10

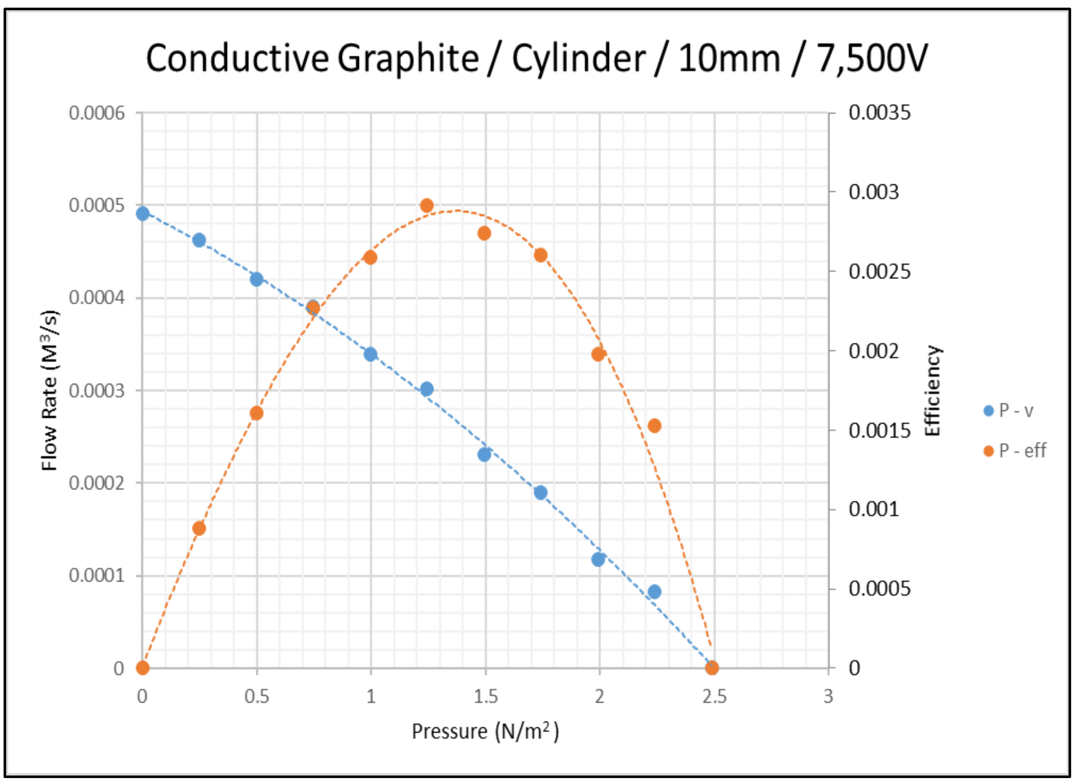


Figure A 11

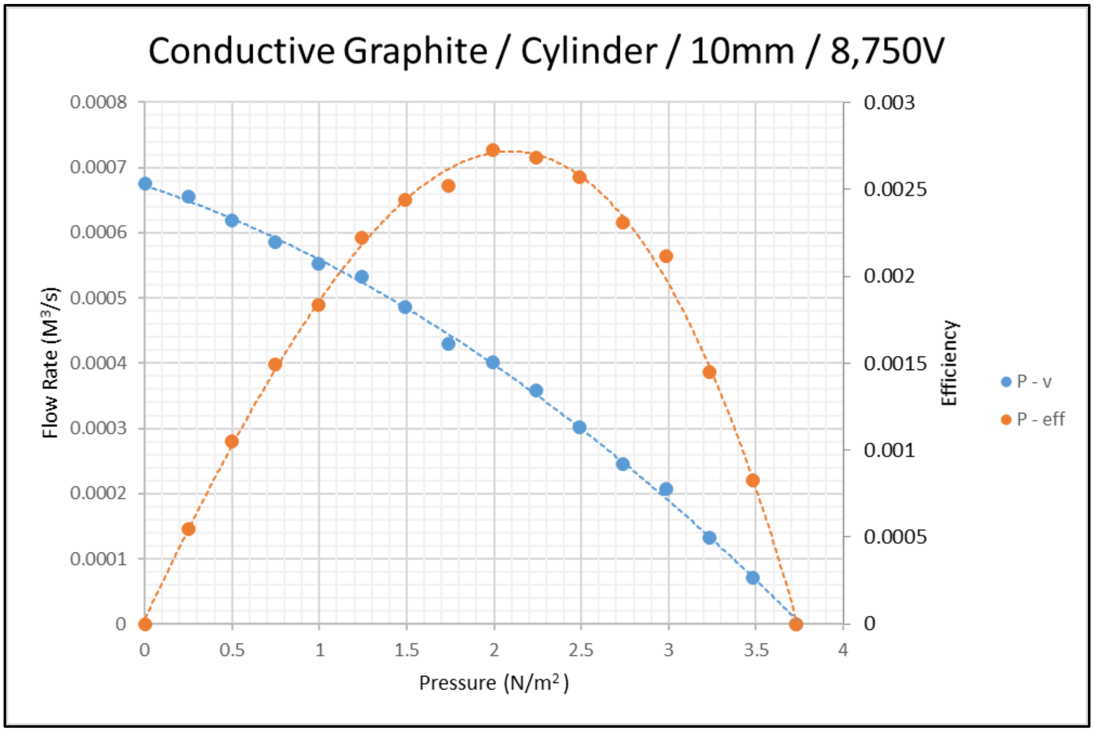


Figure A 12

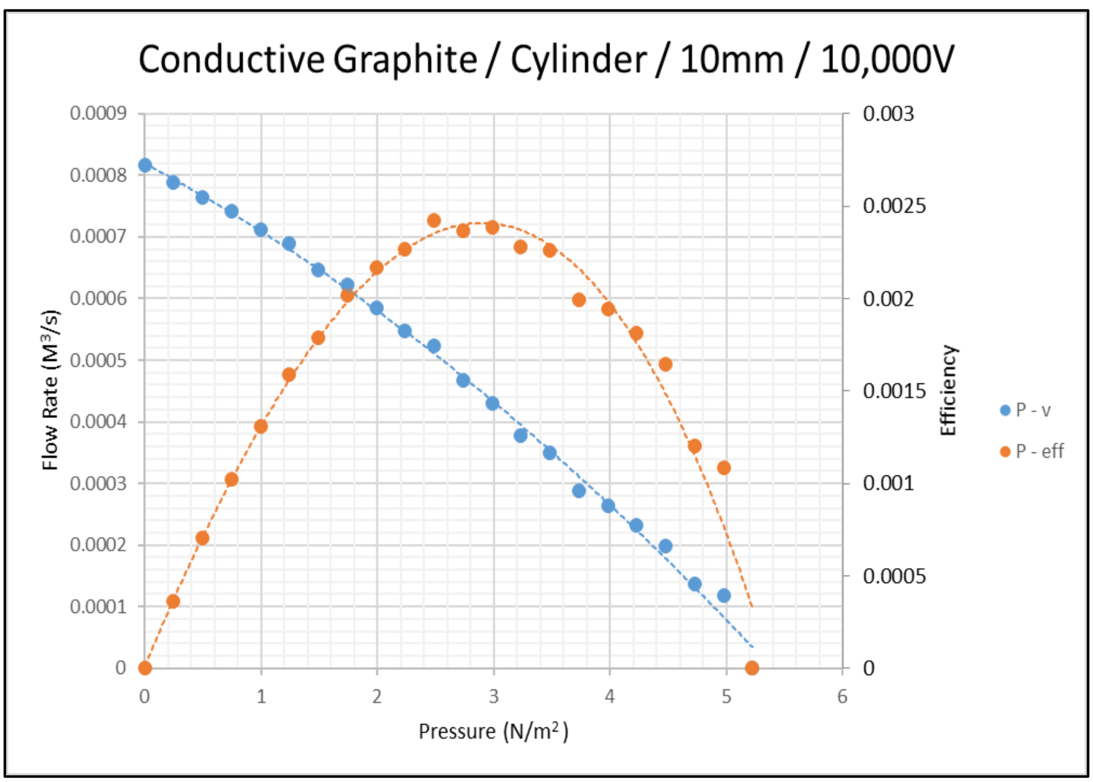


Figure A 13

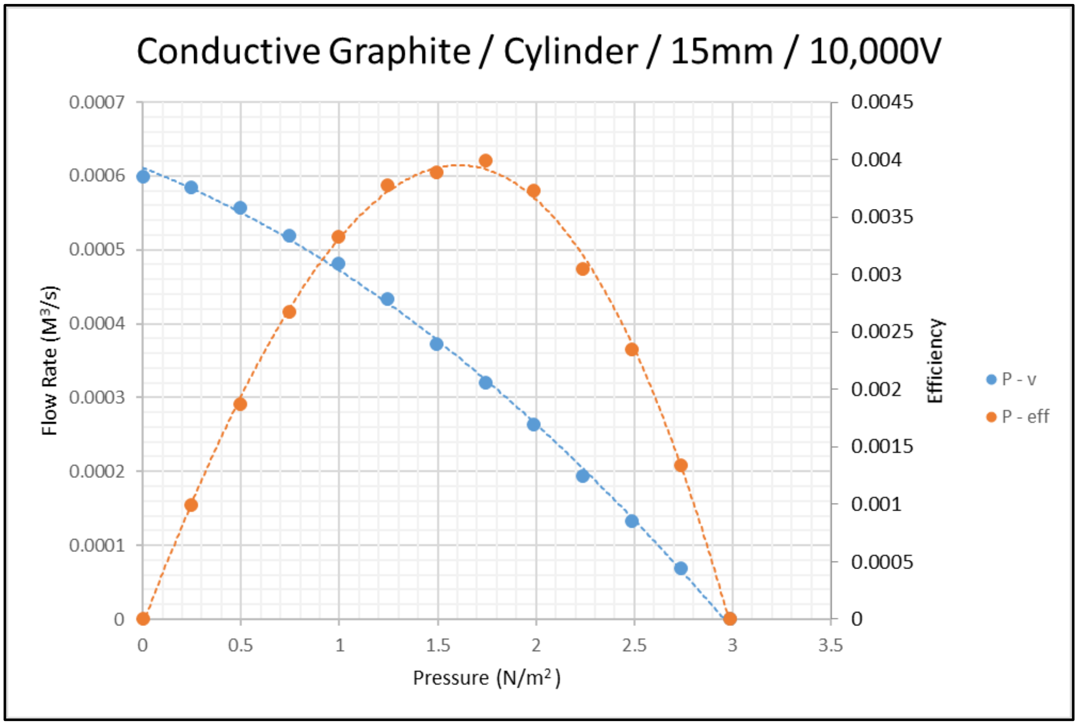


Figure A 14

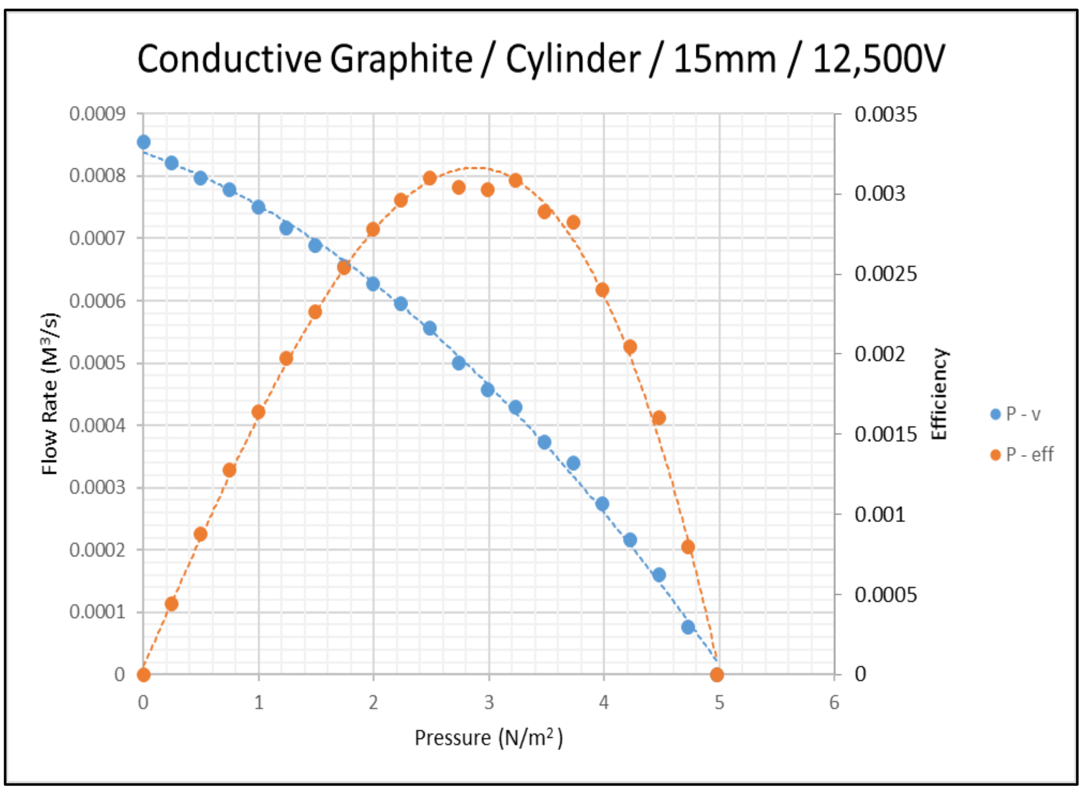


Figure A 15

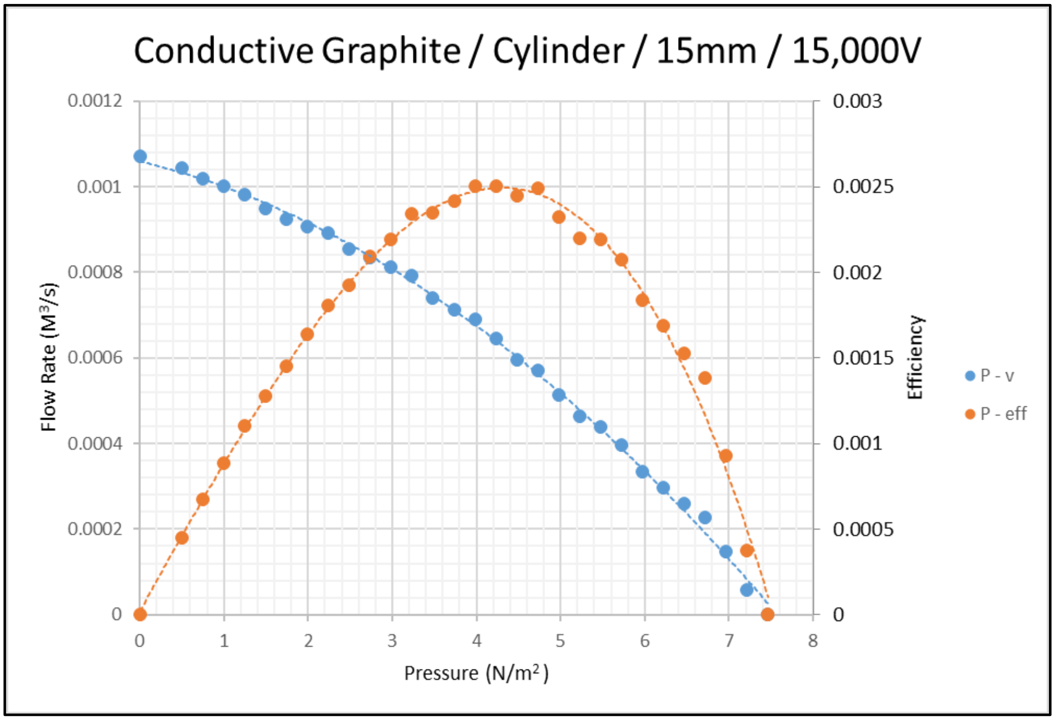


Figure A 16

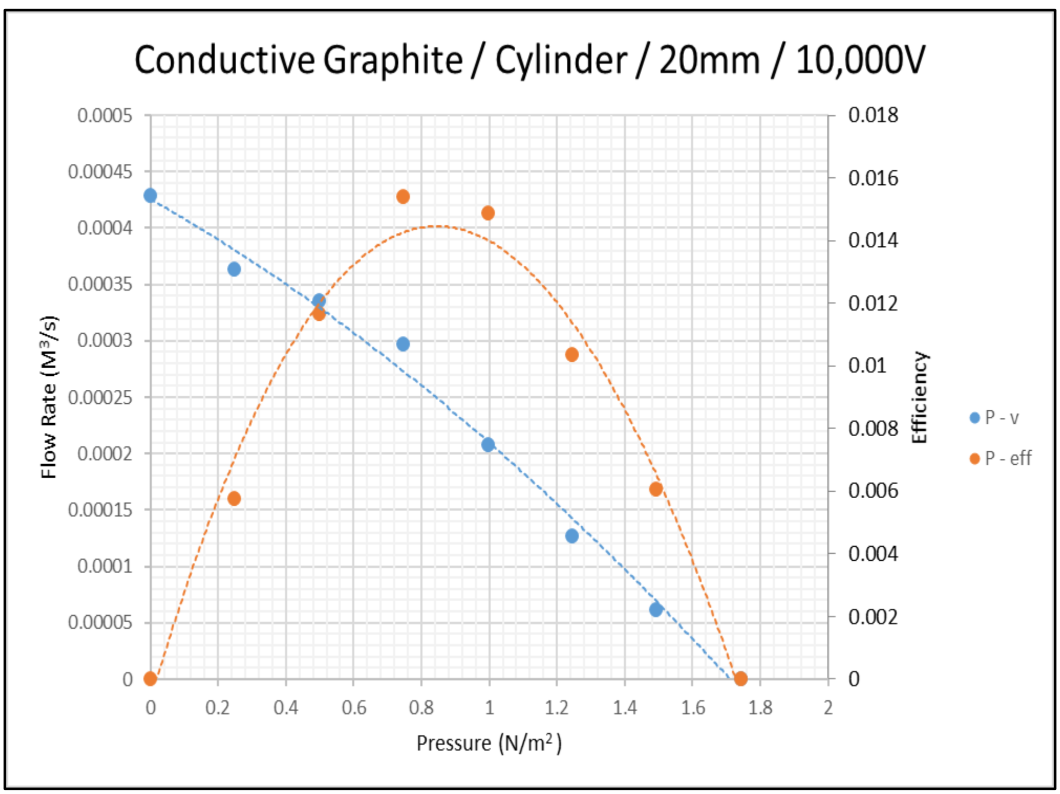


Figure A 17

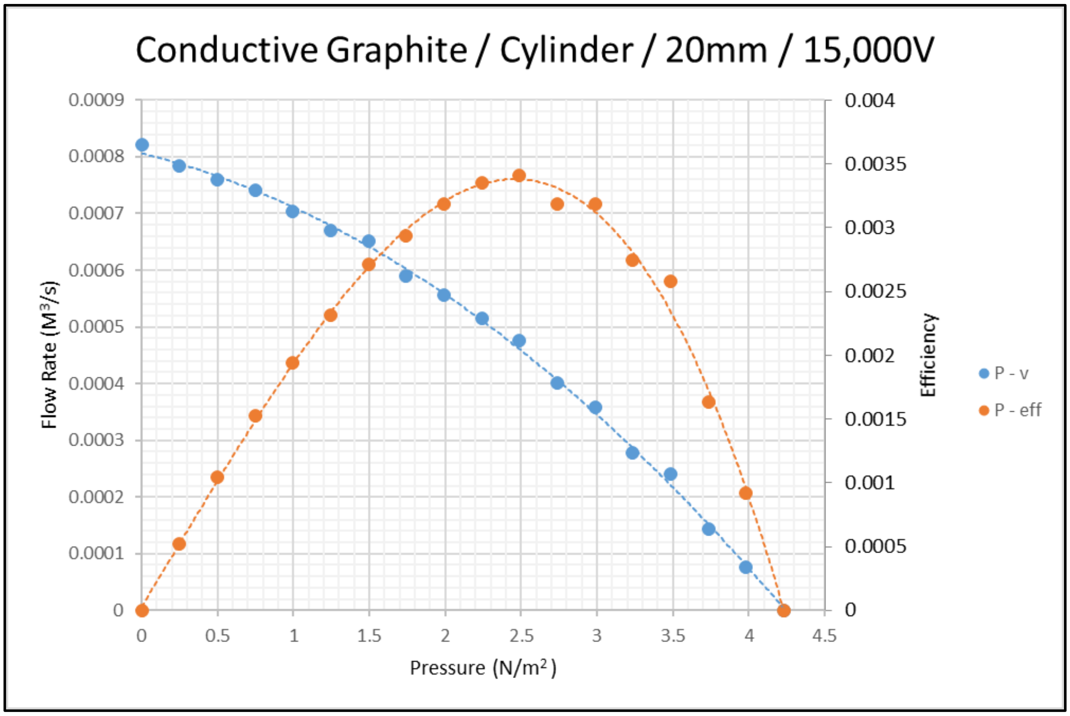


Figure A 18

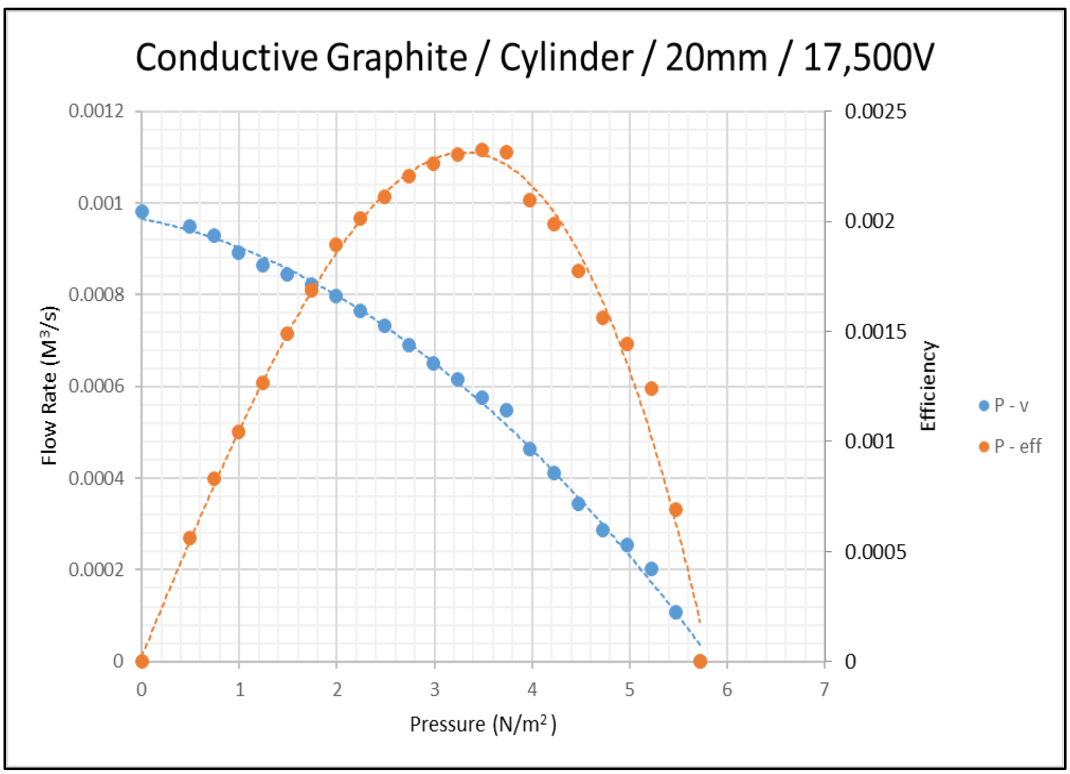


Figure A 19

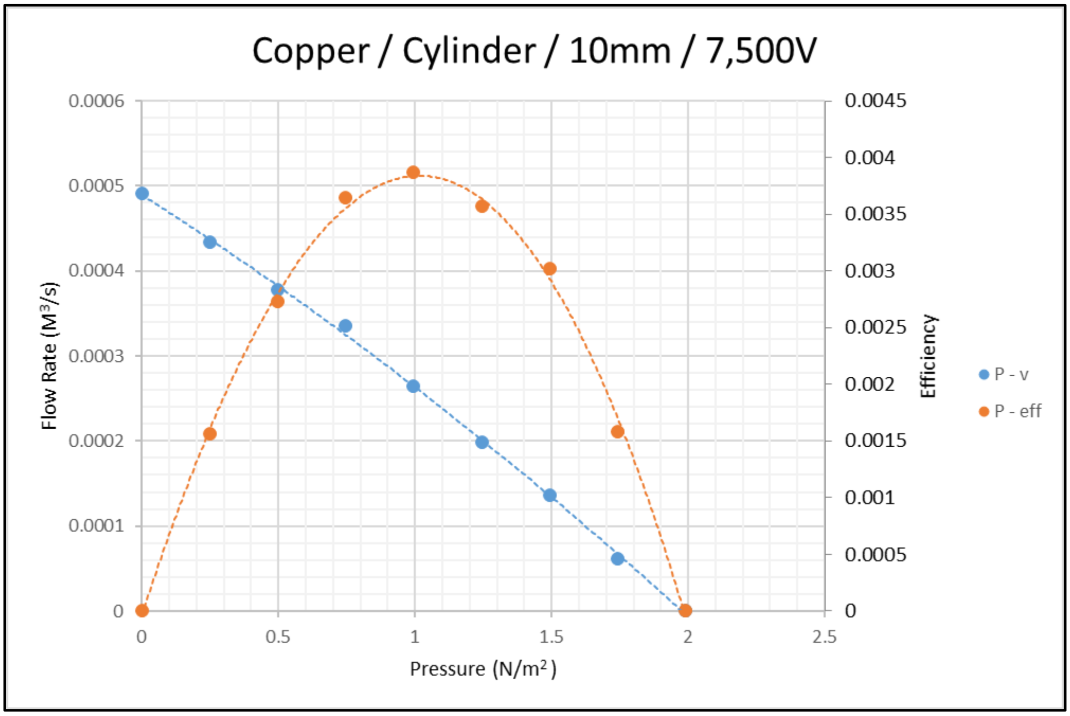


Figure A 20

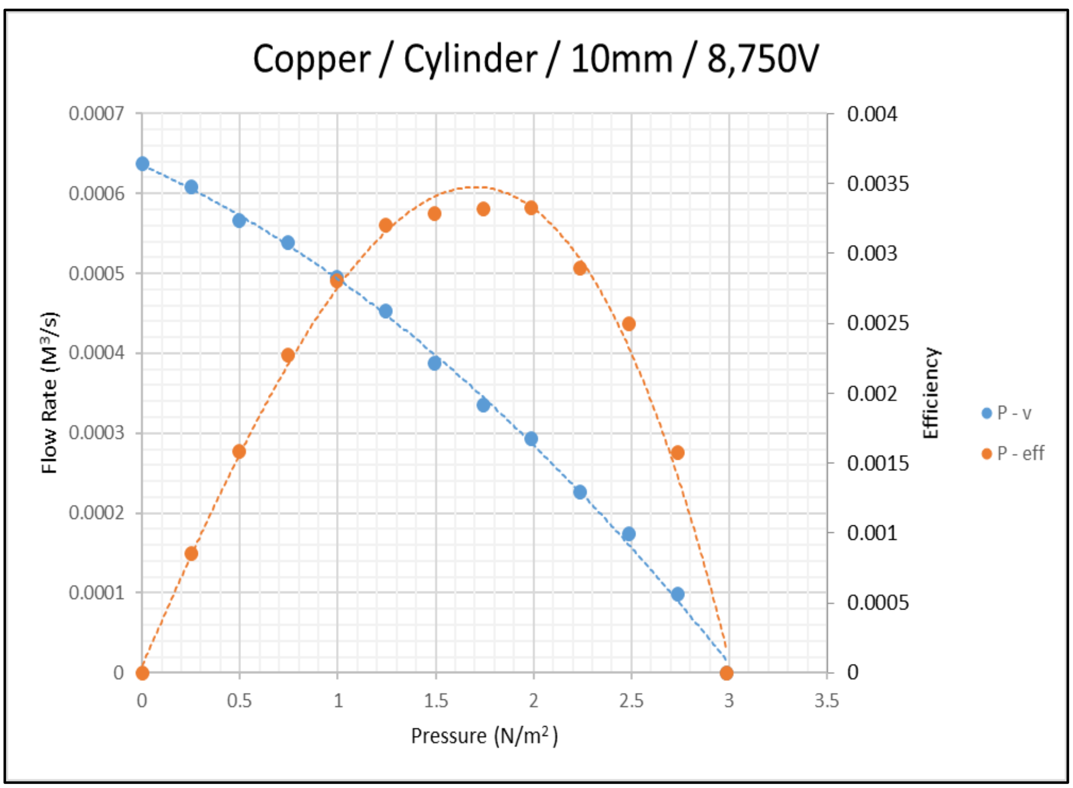


Figure A 21

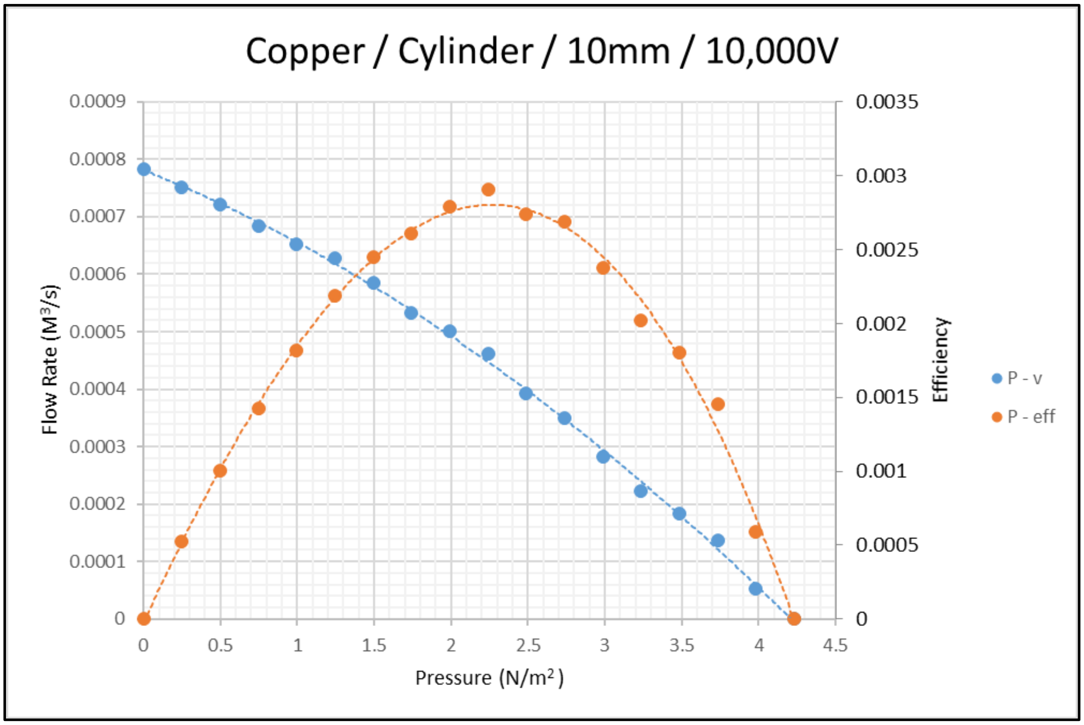


Figure A 22

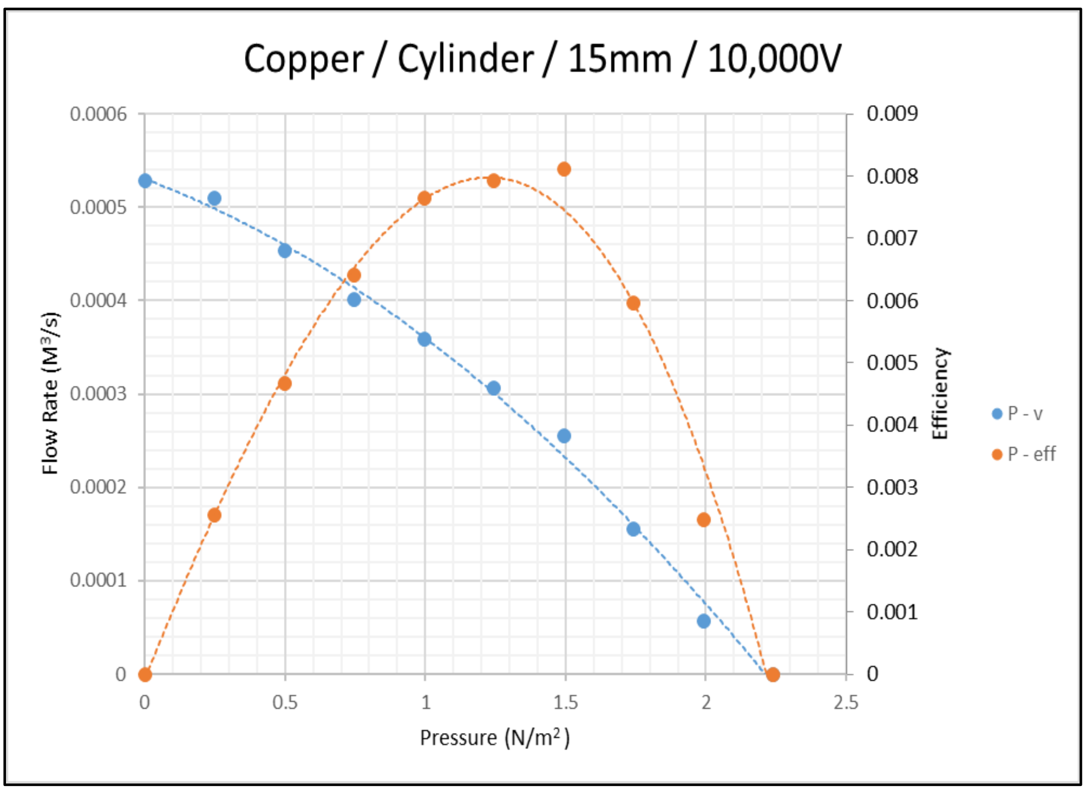


Figure A 23

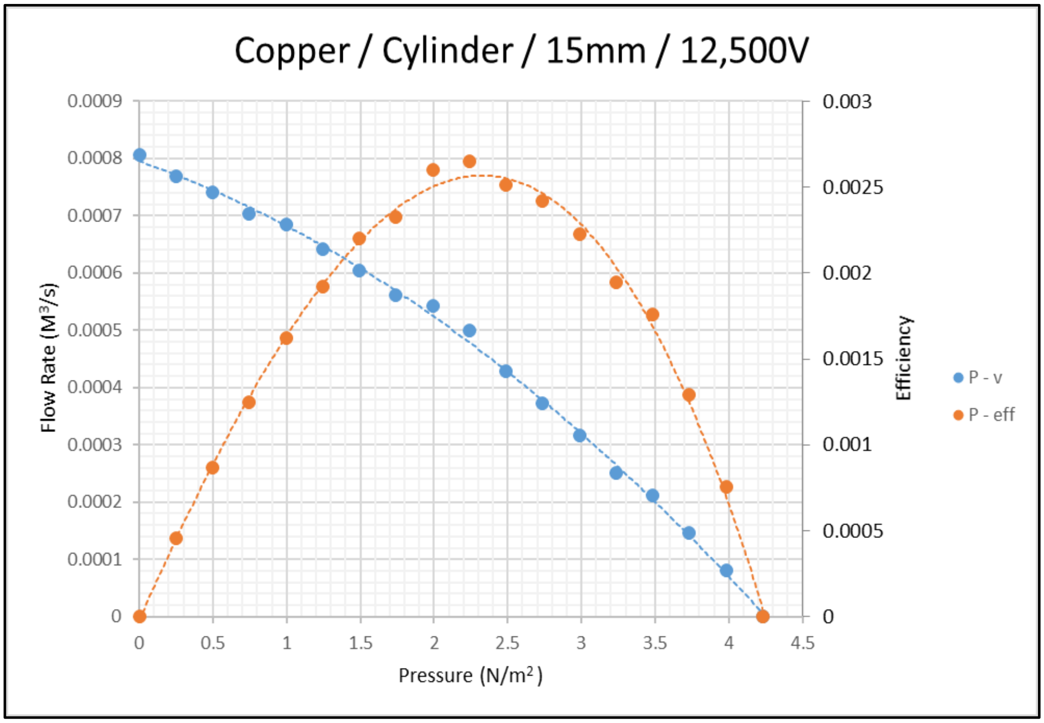


Figure A 24

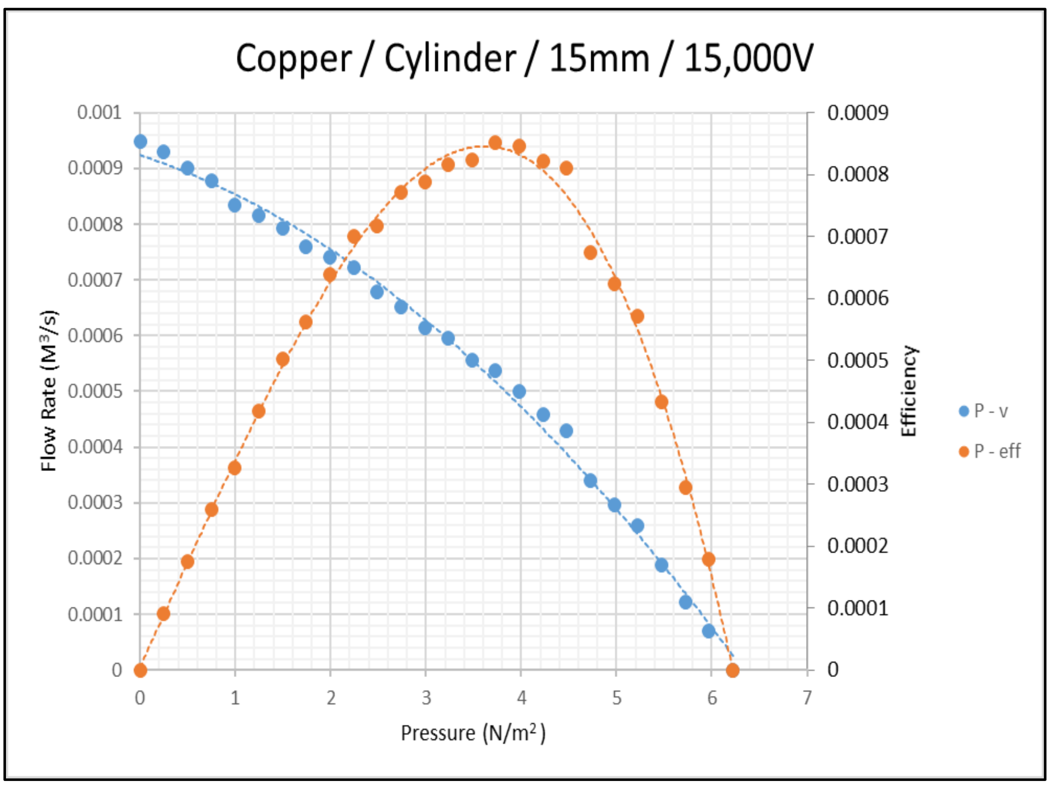


Figure A 25

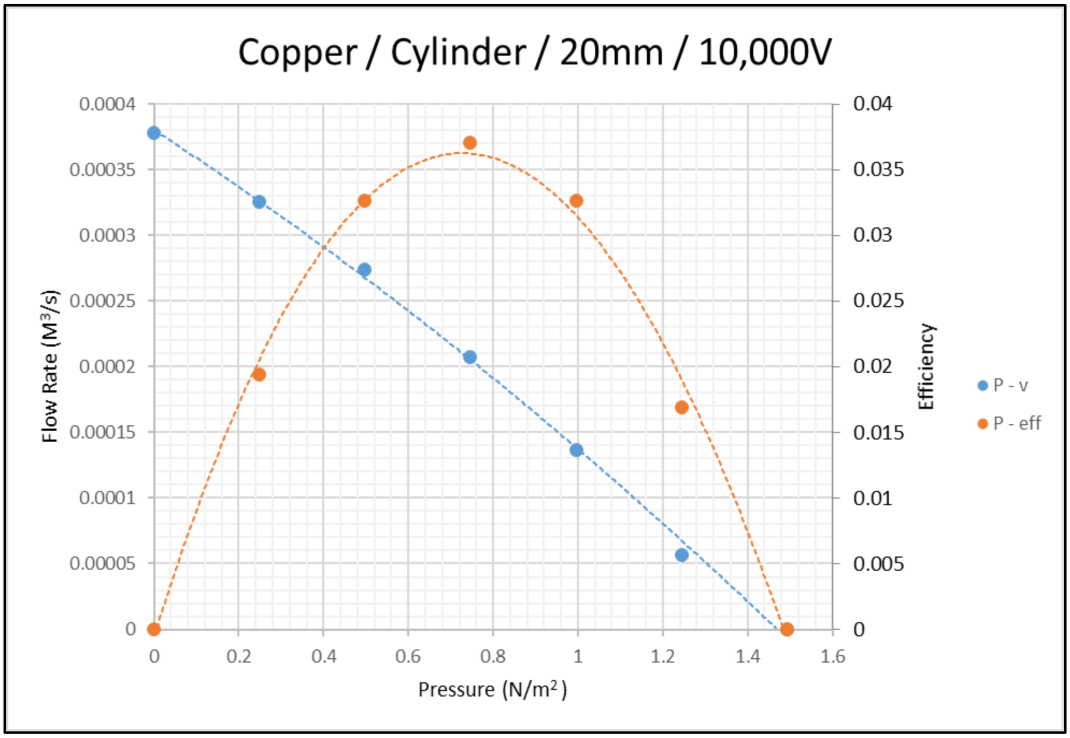


Figure A 26

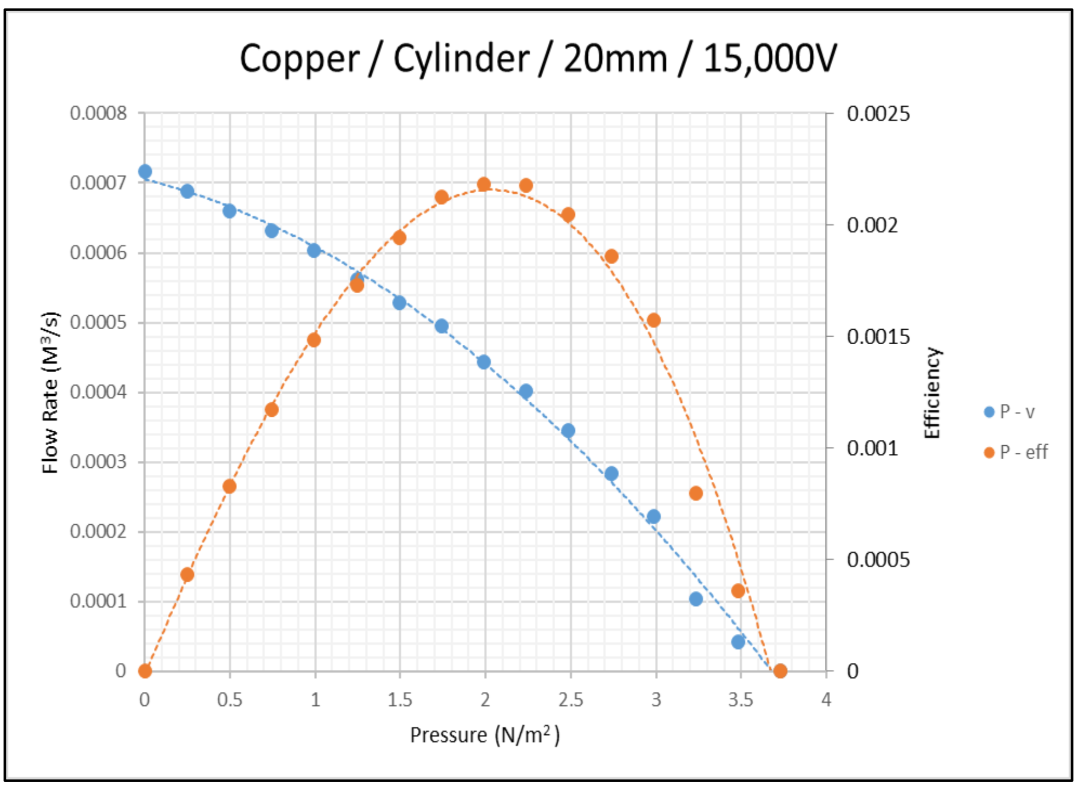


Figure A 27

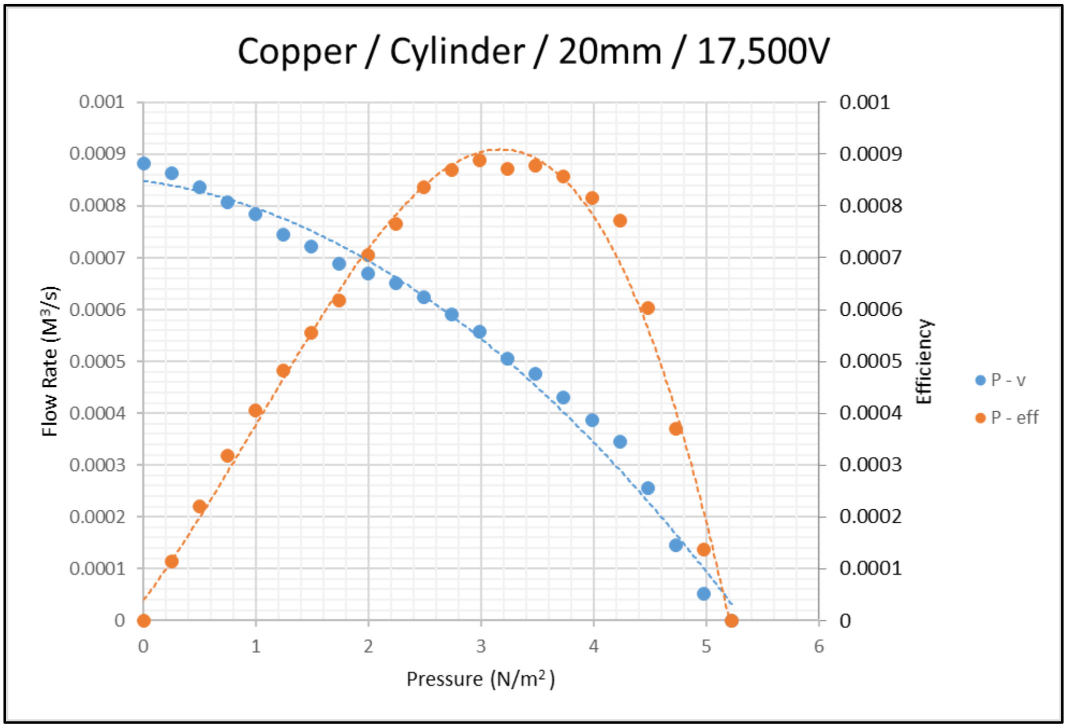


Figure A 28

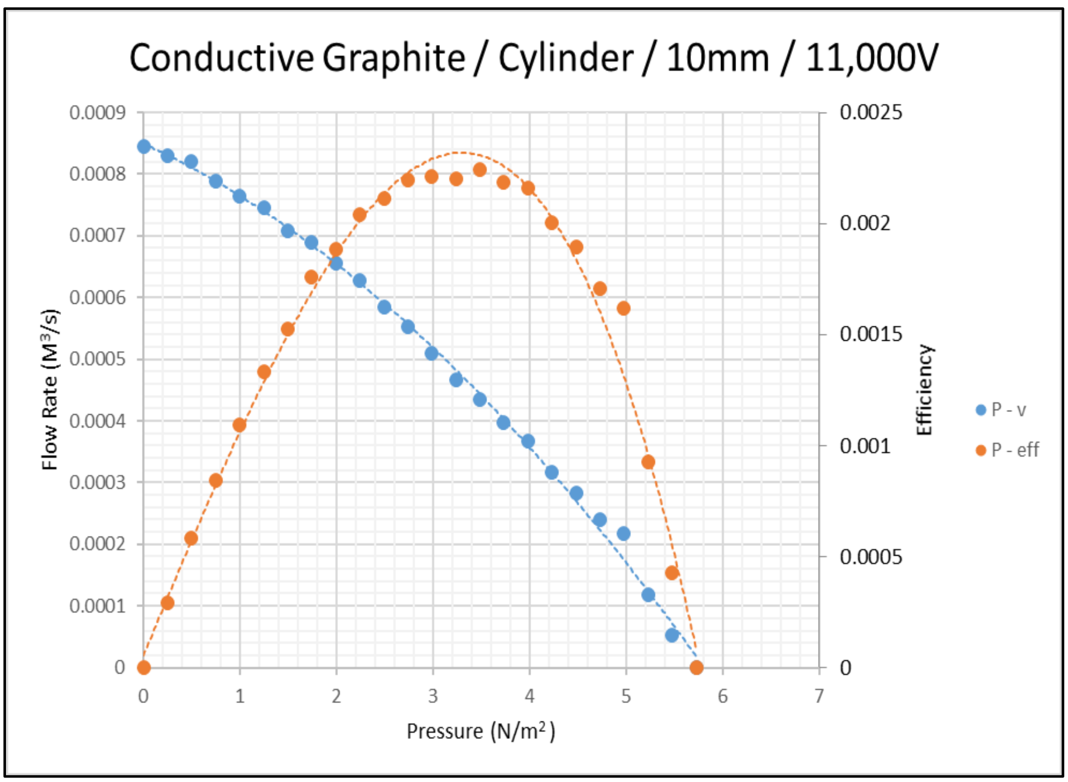


Figure A 29

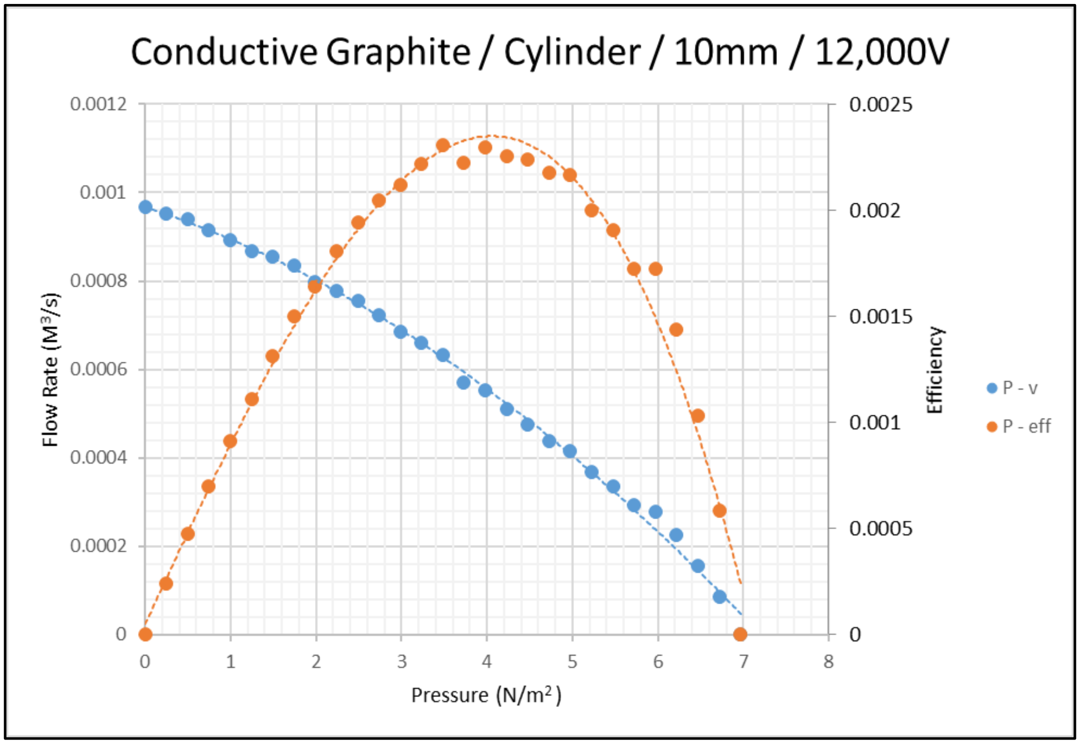


Figure A 30

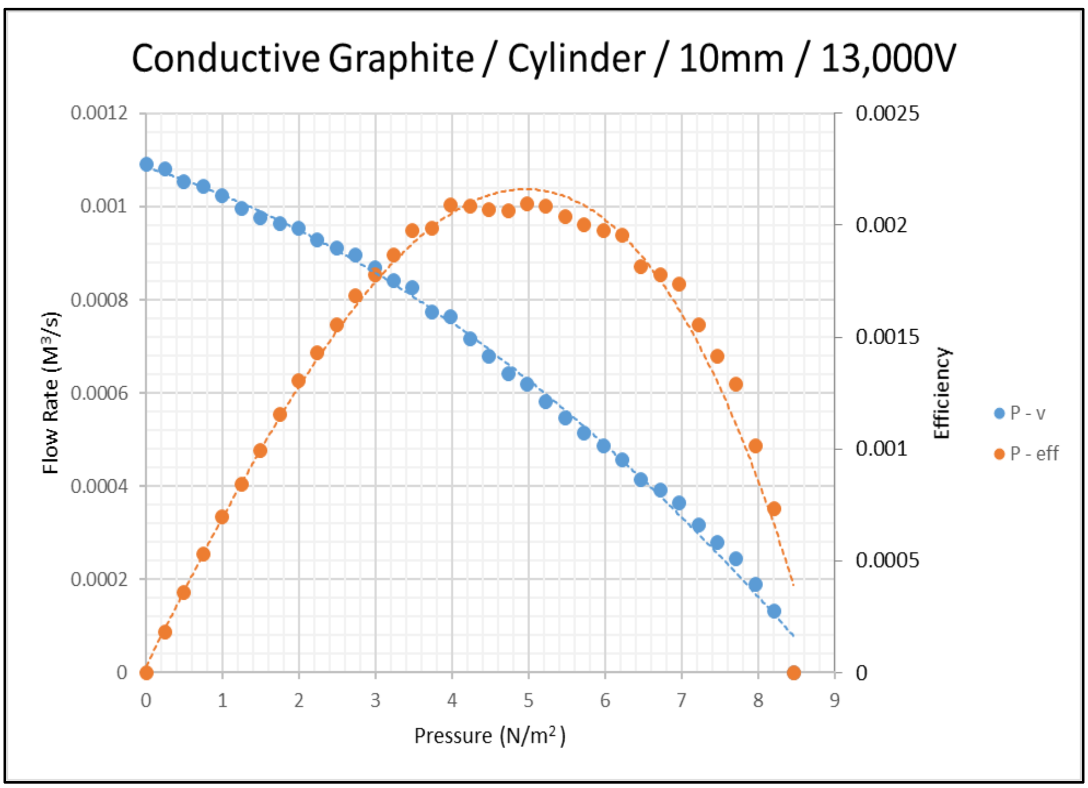


Figure A 31

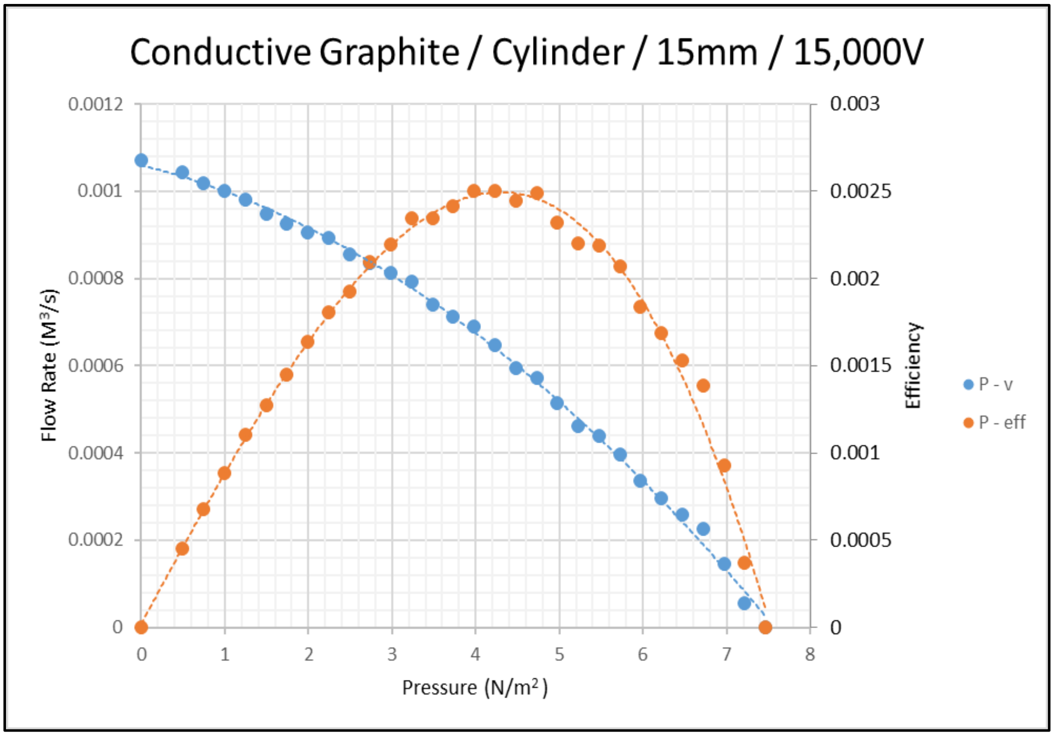


Figure A 32

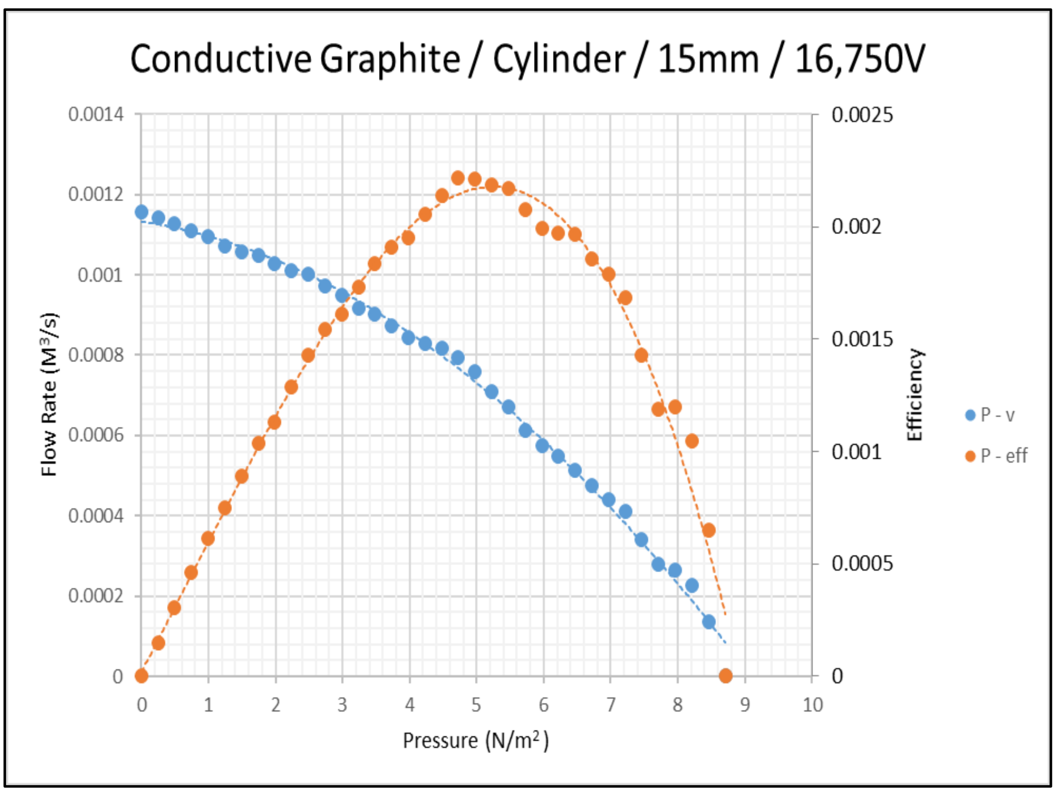


Figure A 33

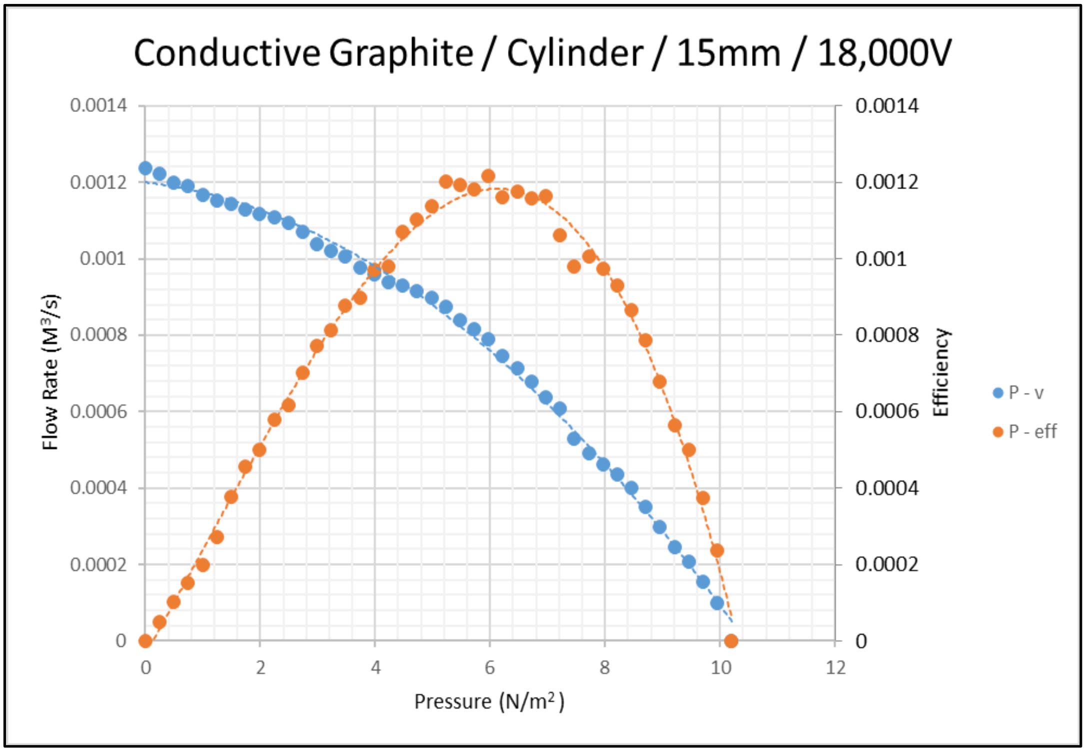


Figure A 34

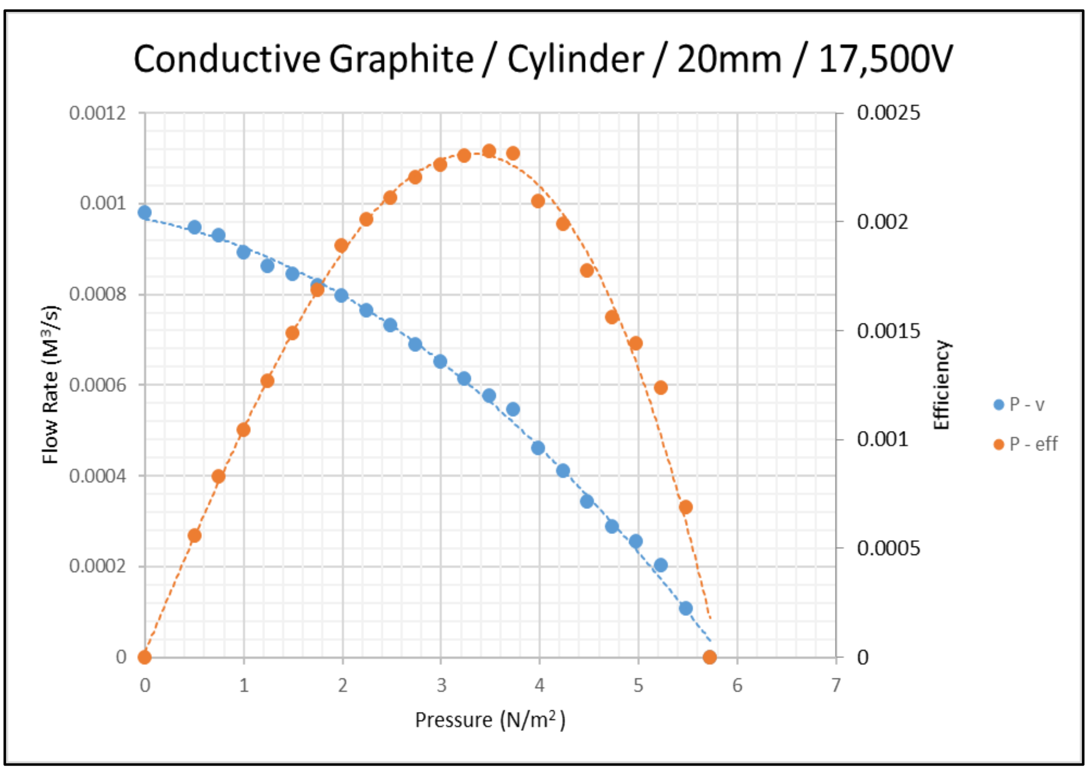


Figure A 35

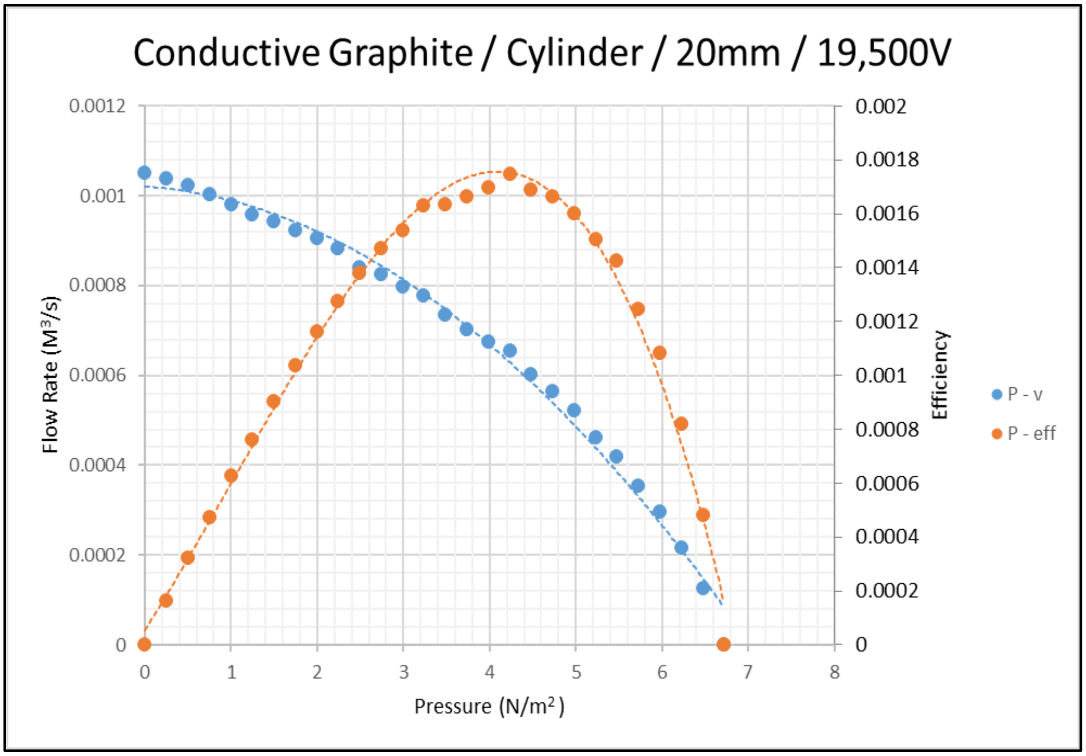


Figure A 36

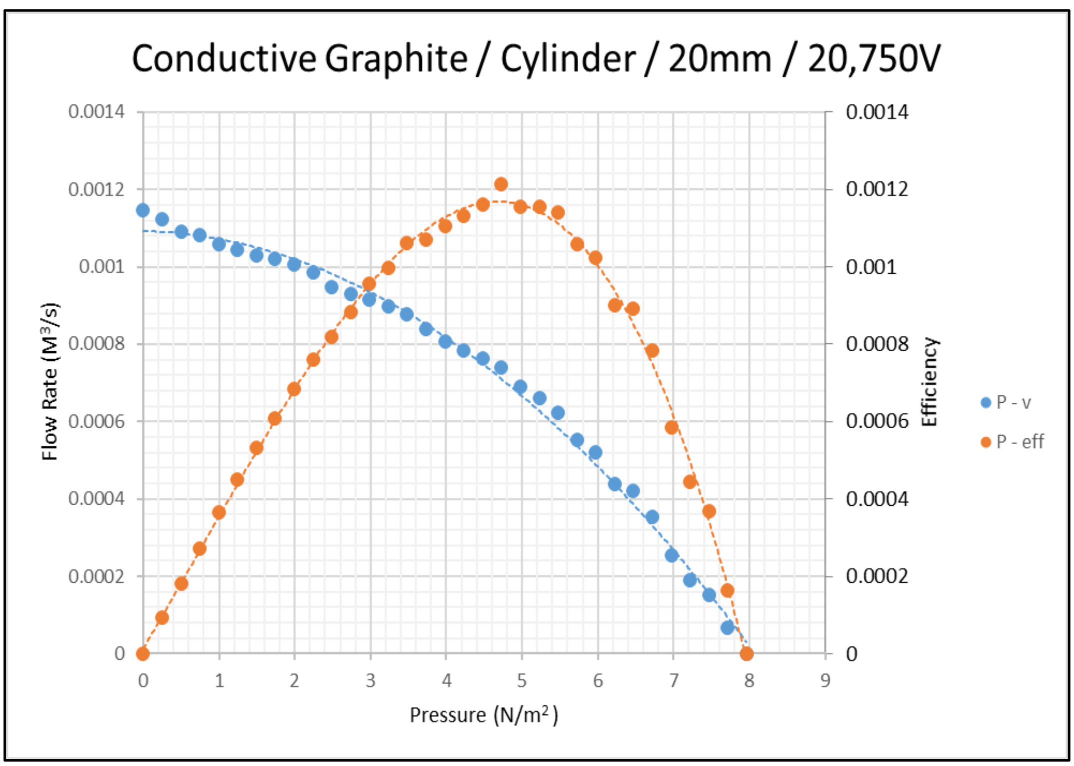


Figure A 37

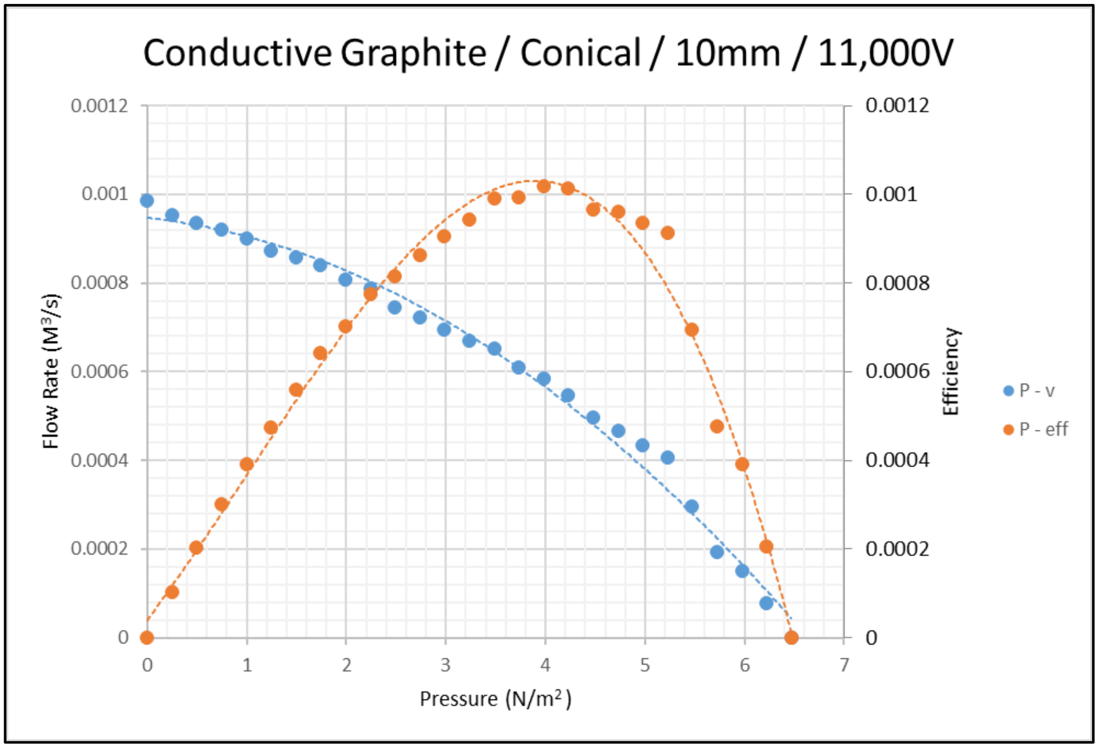
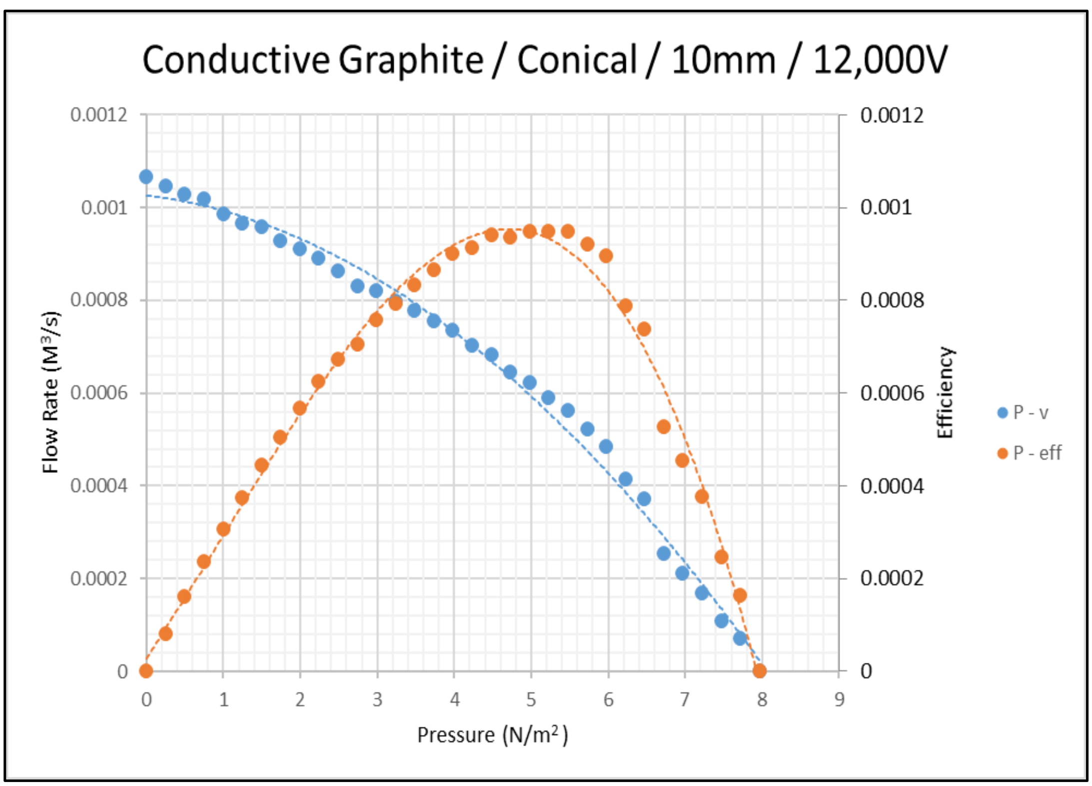


Figure A 38



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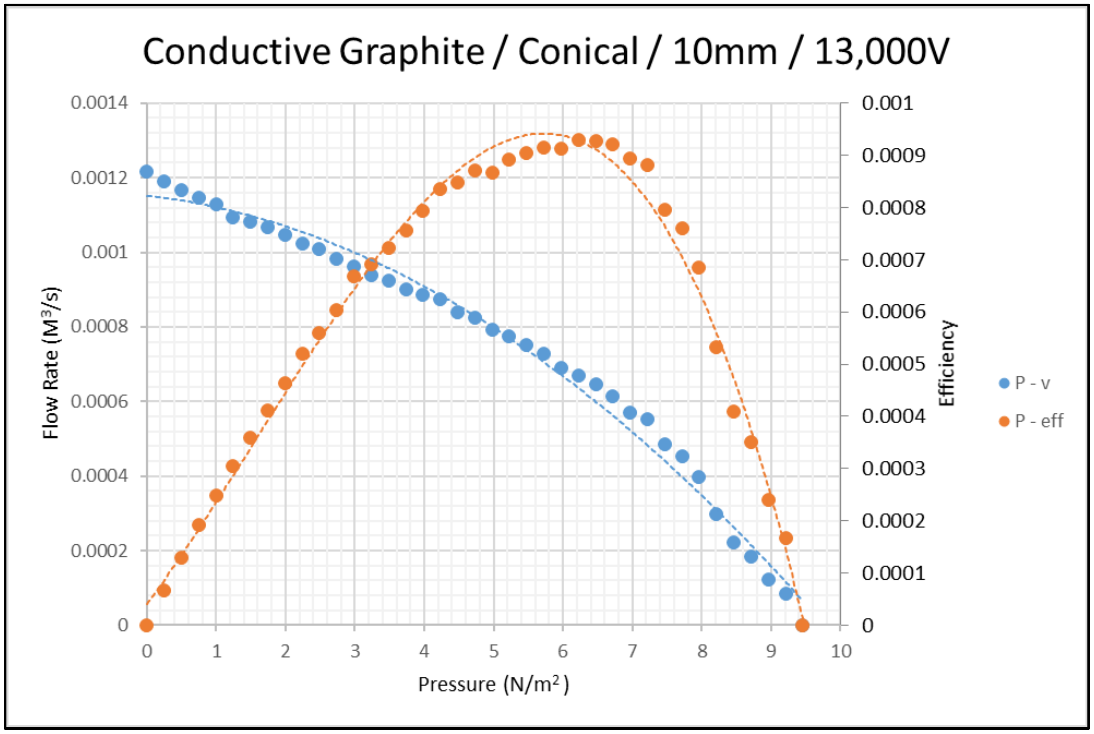

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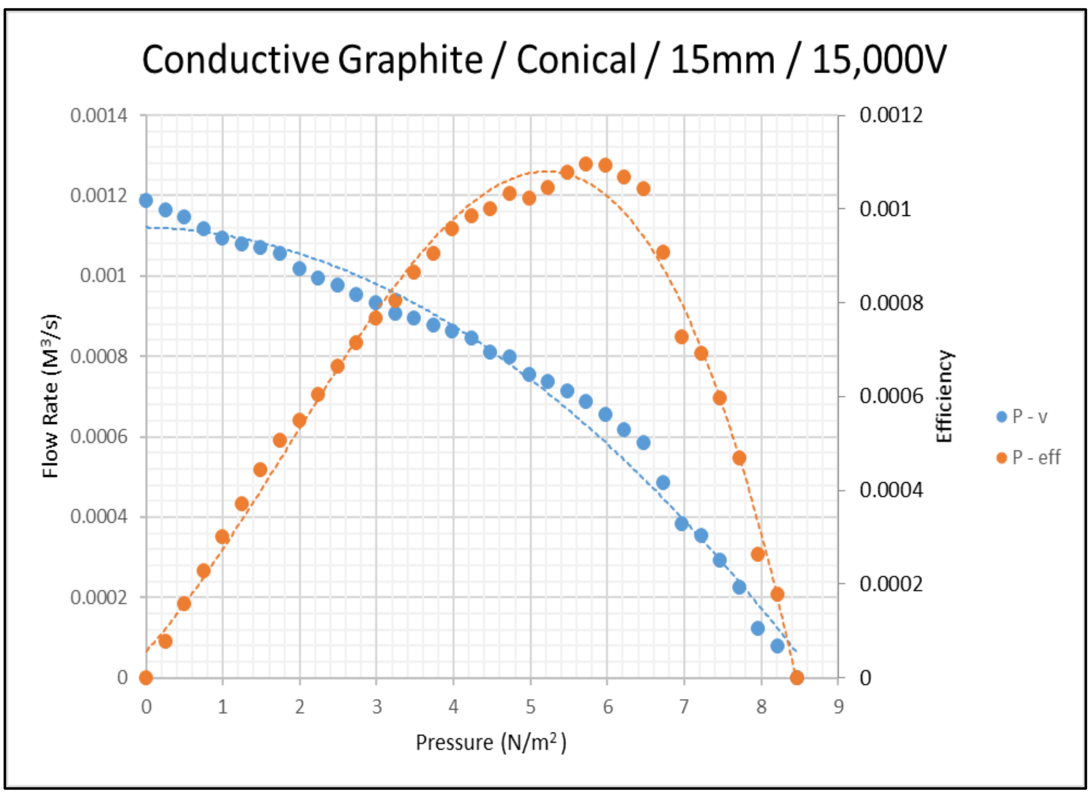

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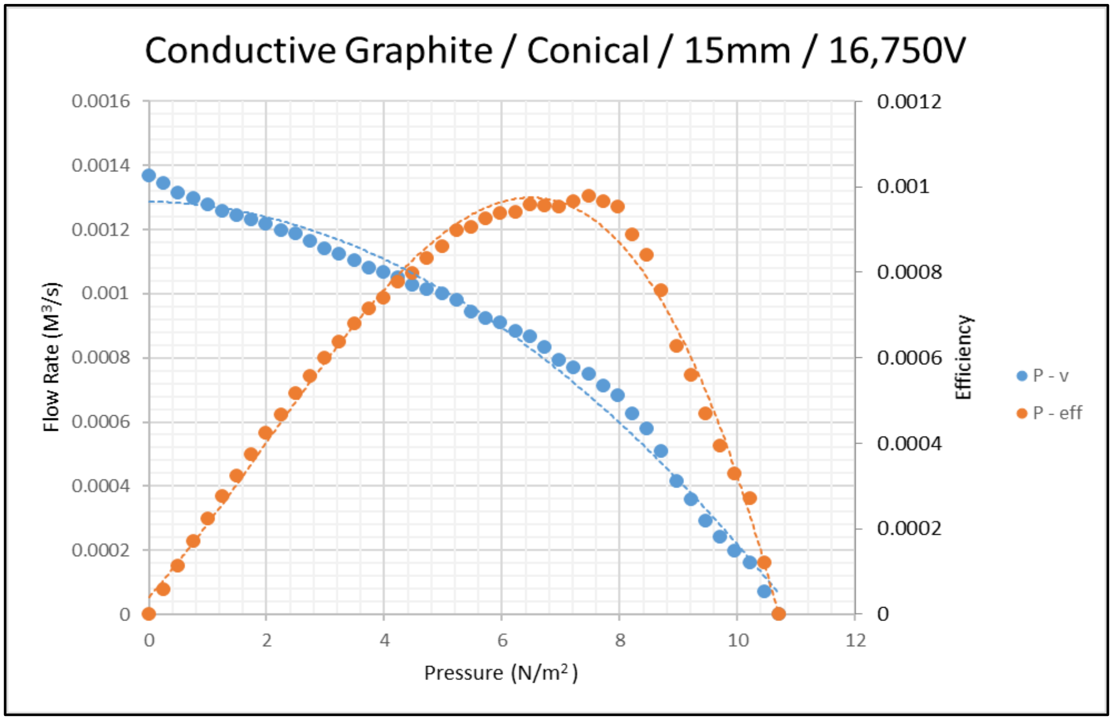

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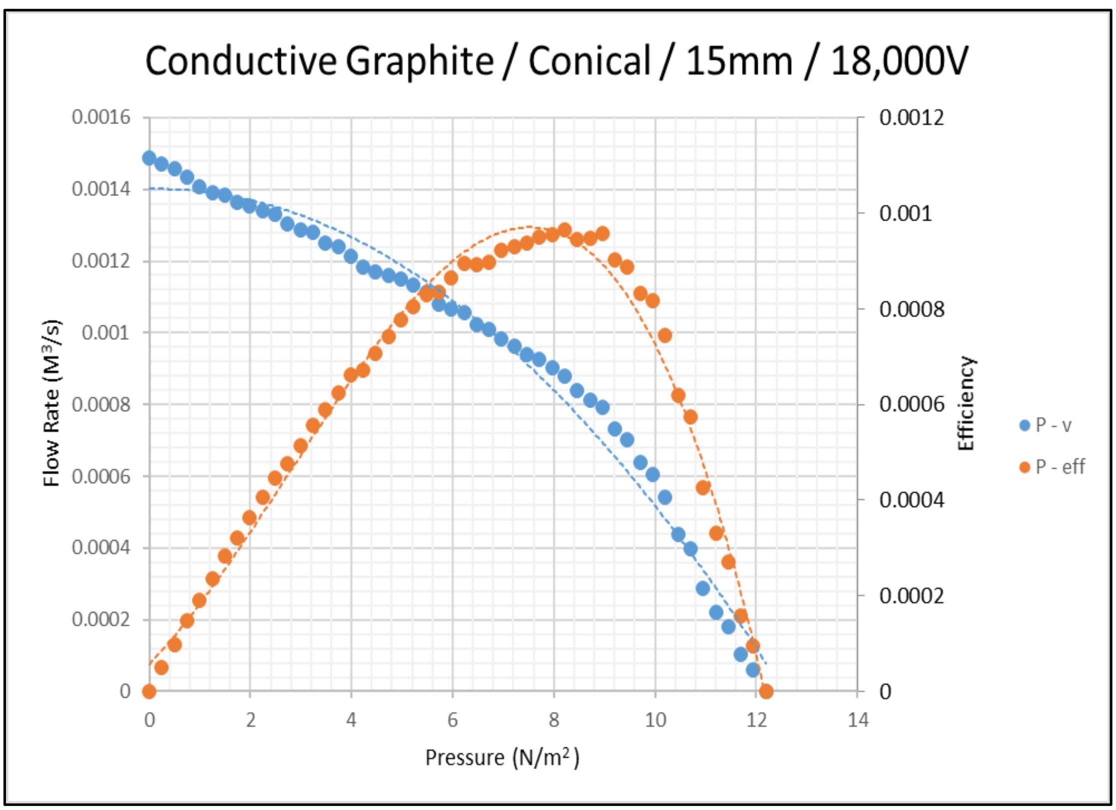

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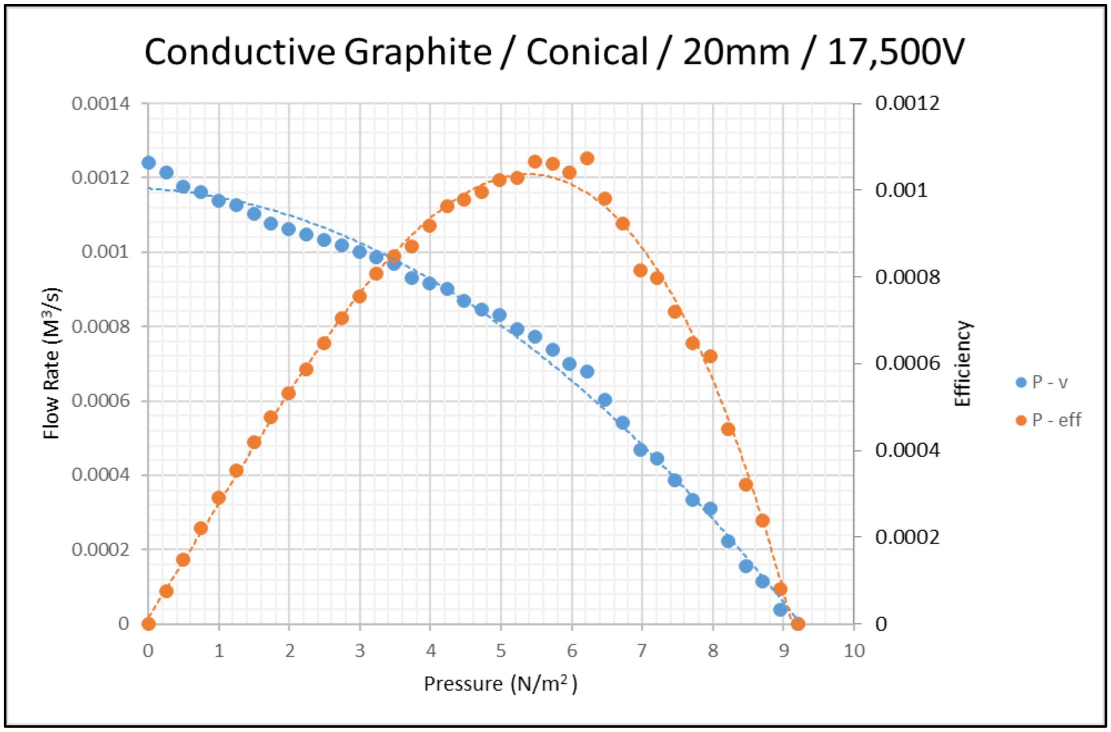


Figure A 44

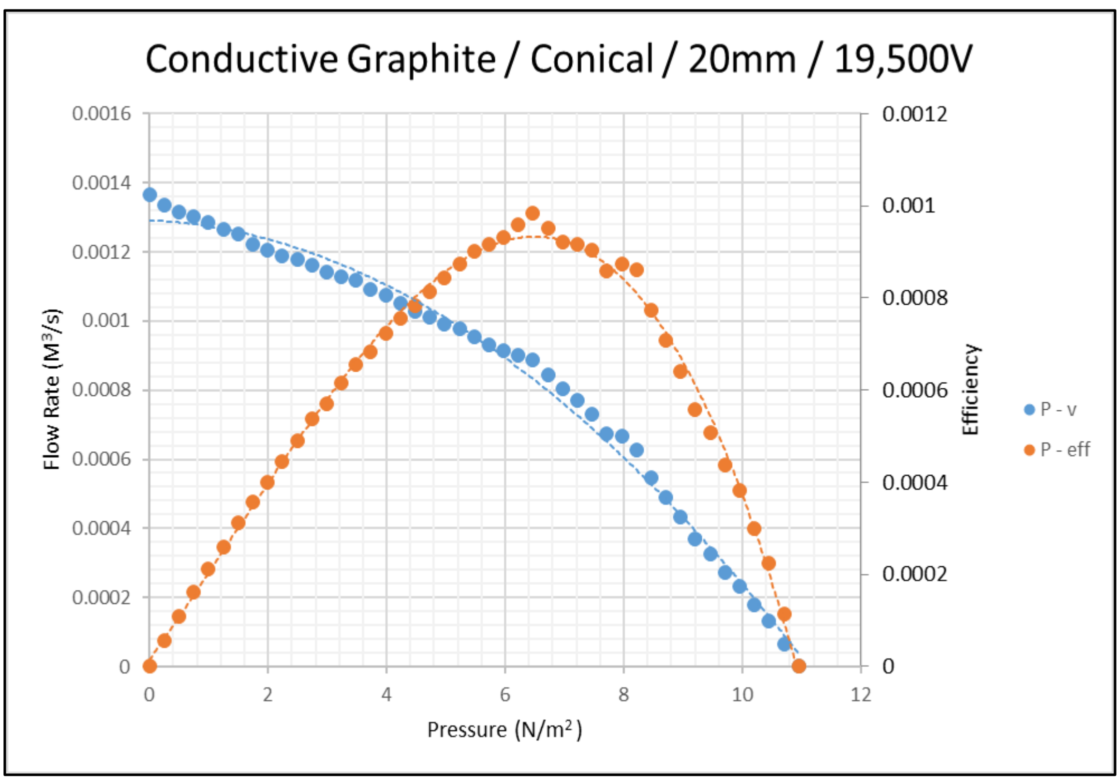


Figure A 45

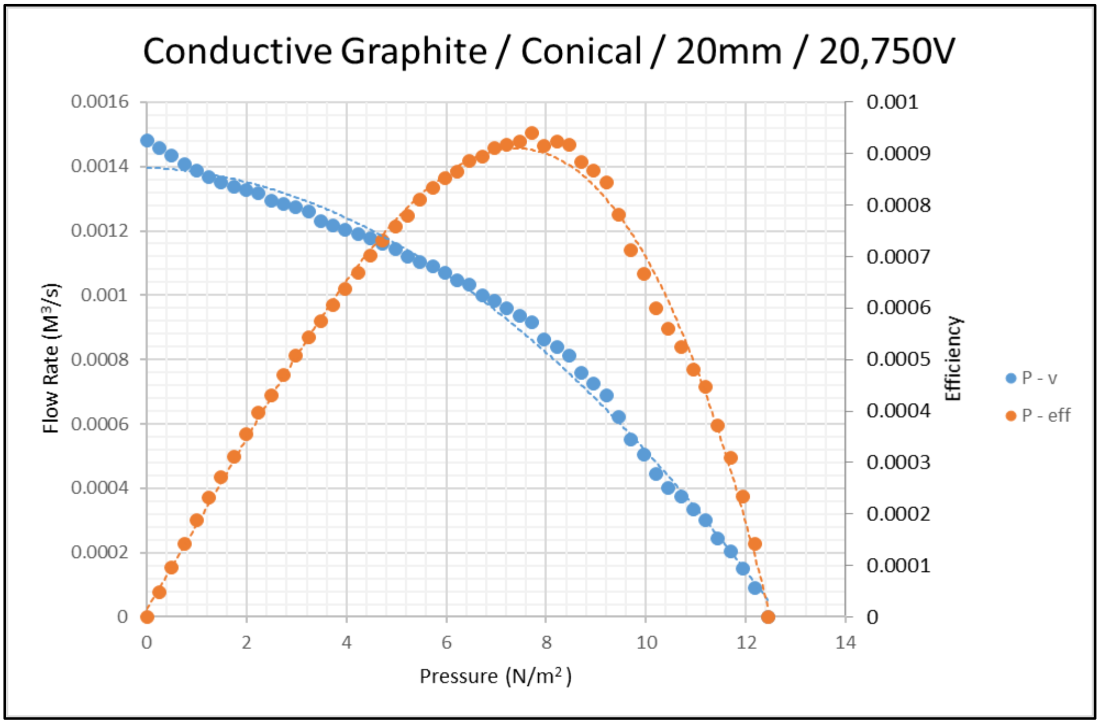


Figure A 46

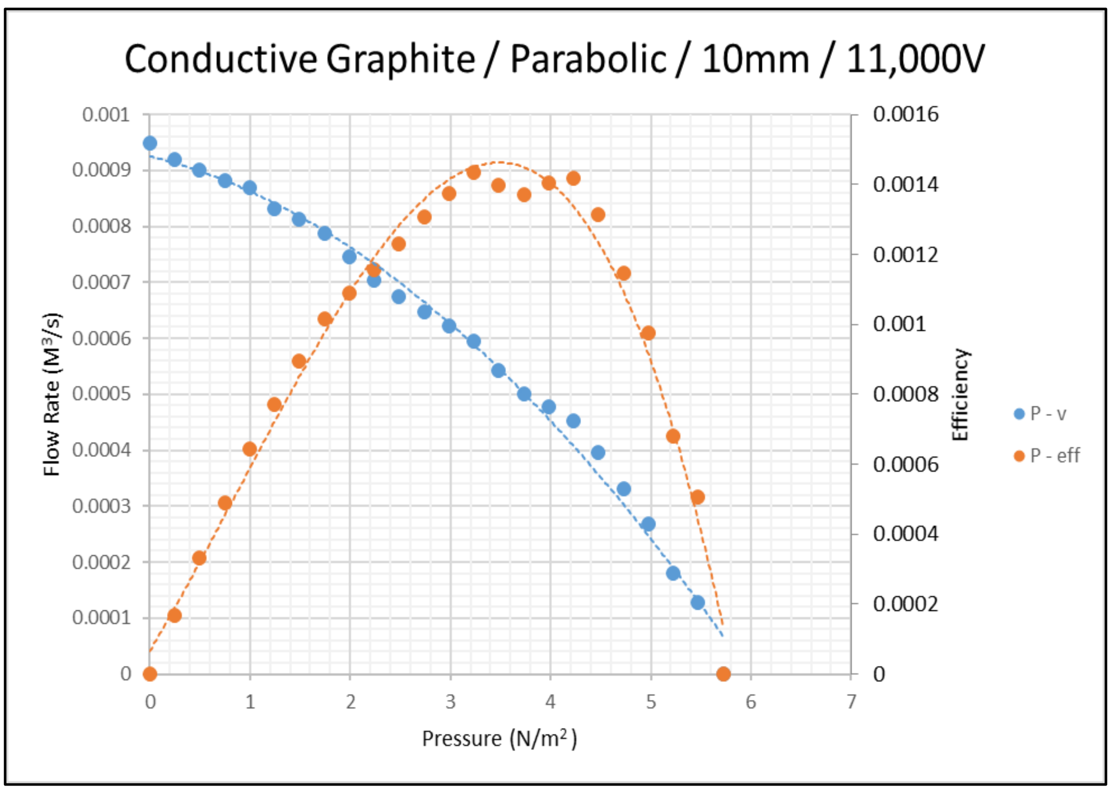


Figure A 47

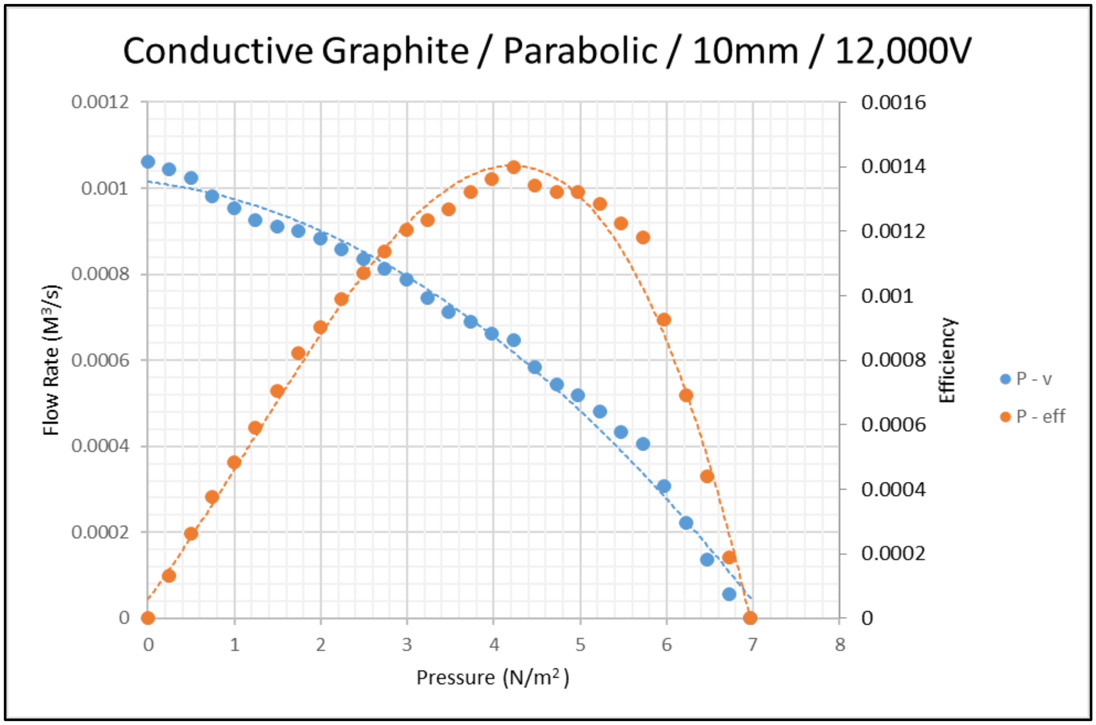


Figure A 48

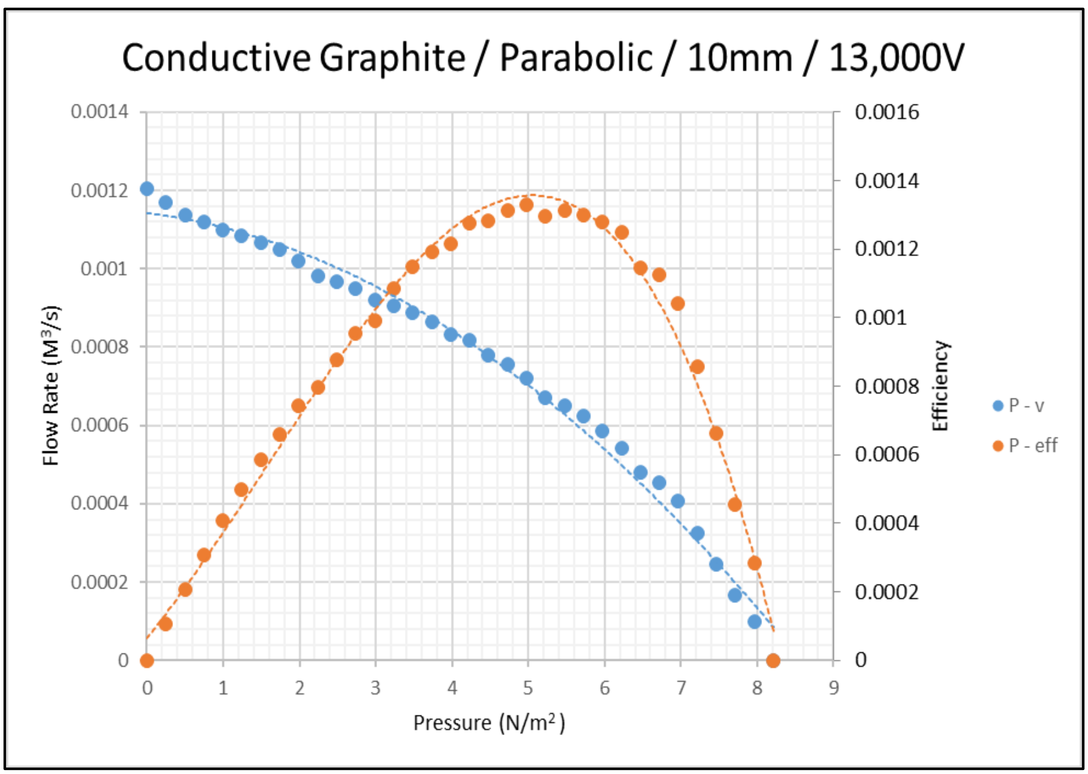


Figure A 49

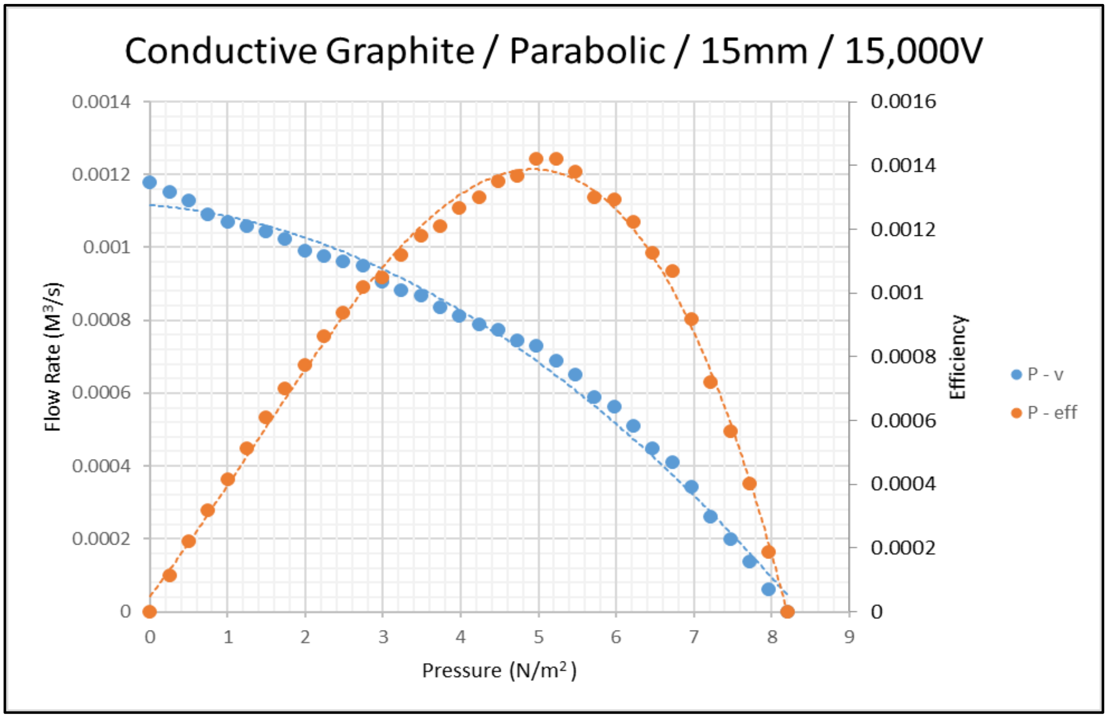


Figure A 50

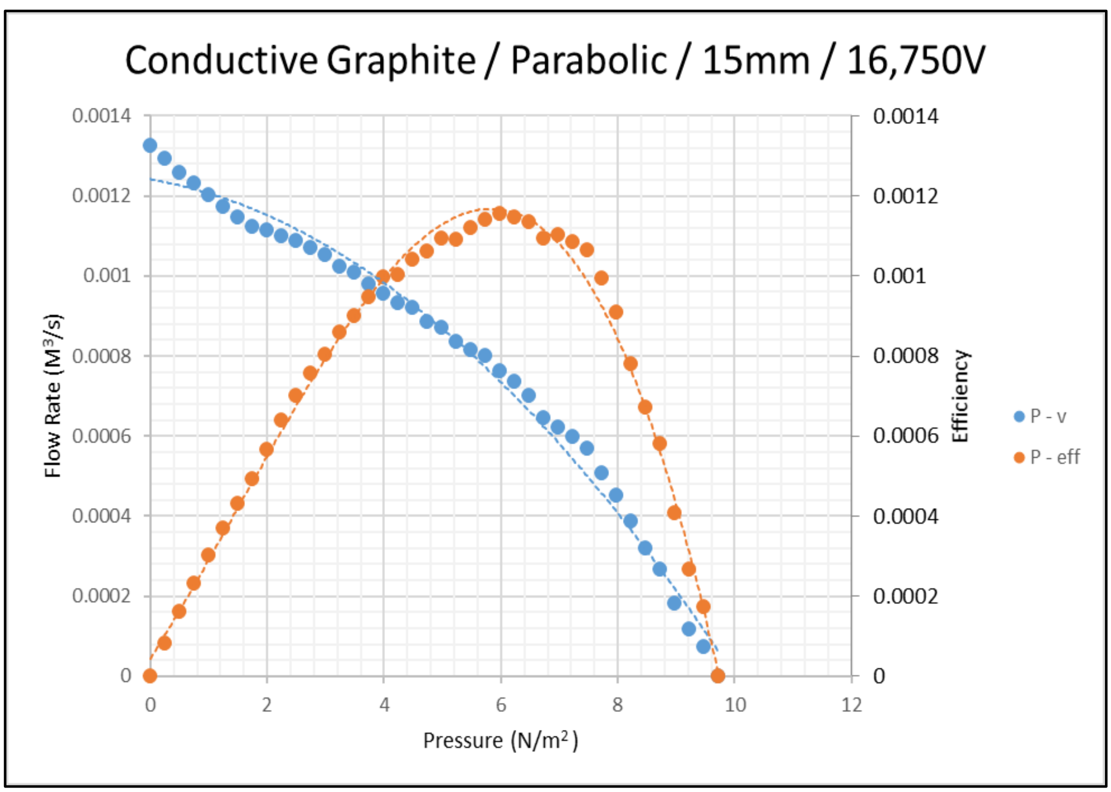


Figure A 51

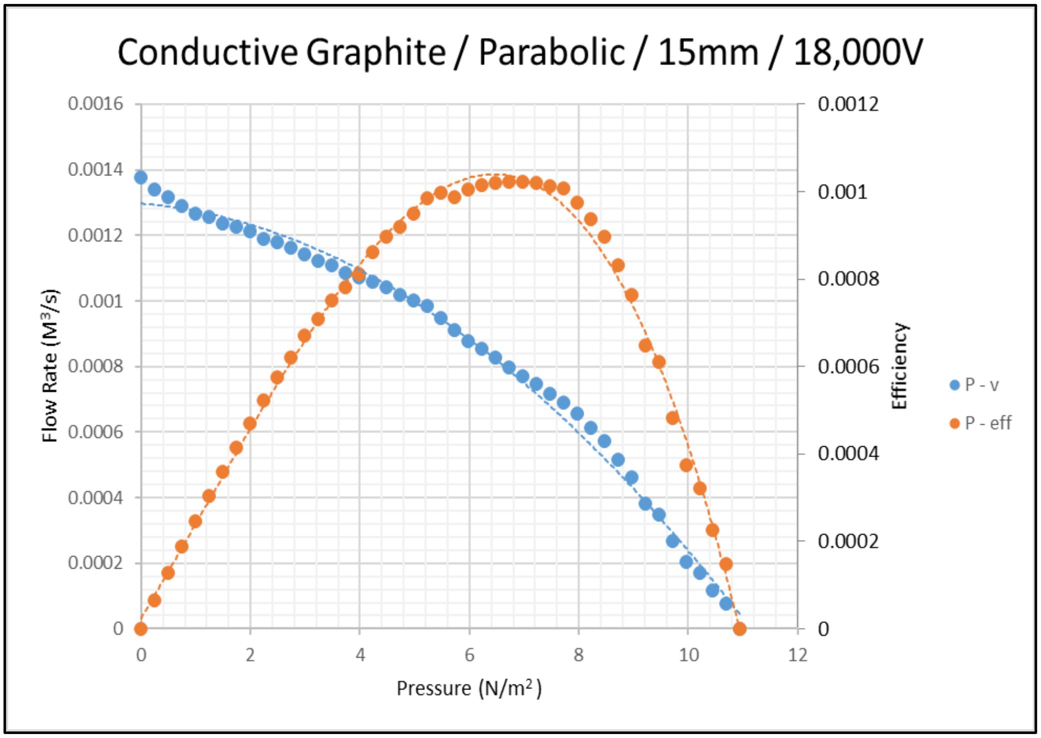


Figure A 52

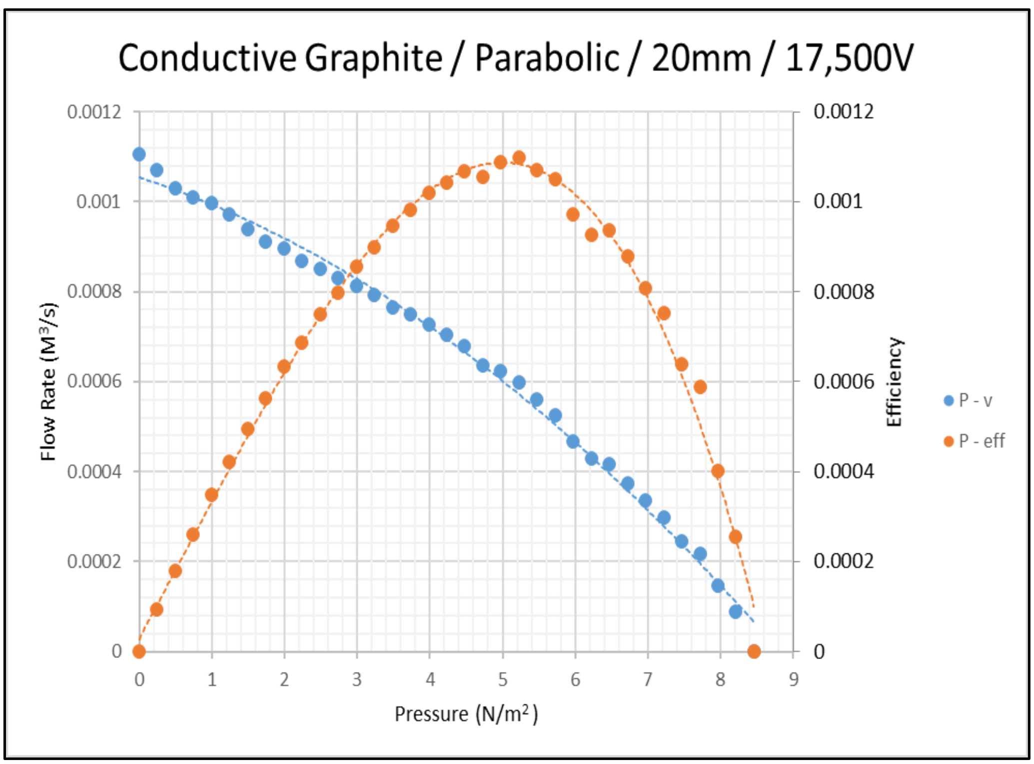


Figure A 53

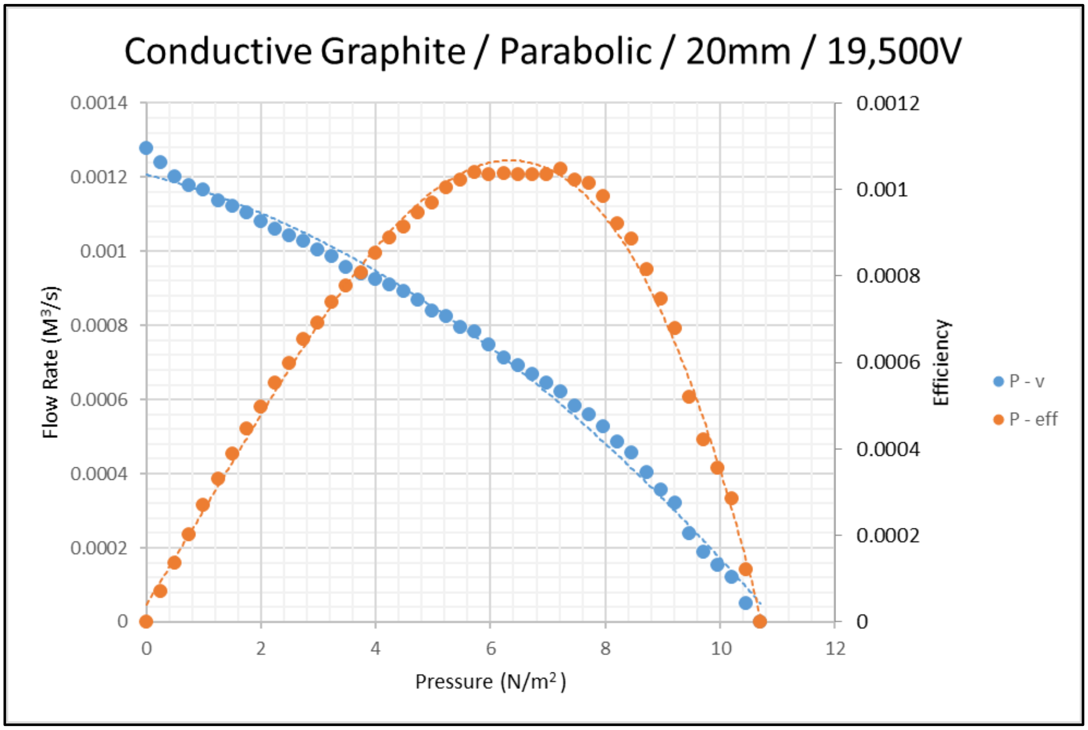


Figure A 54

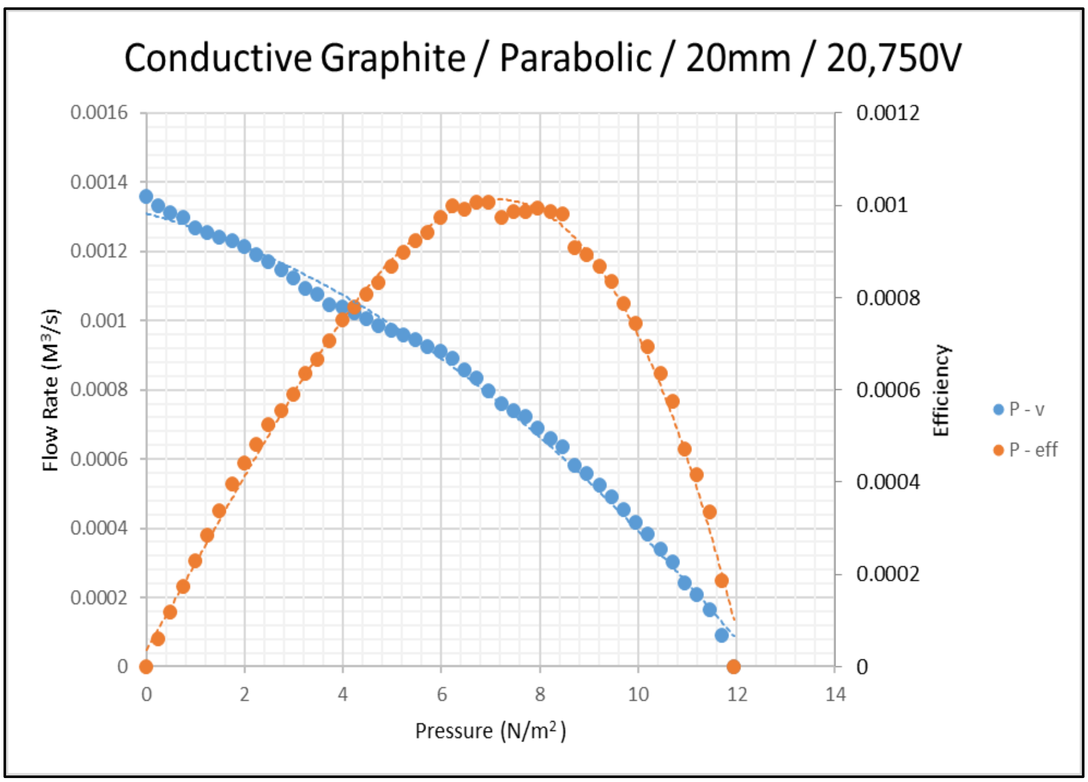


Figure A 55

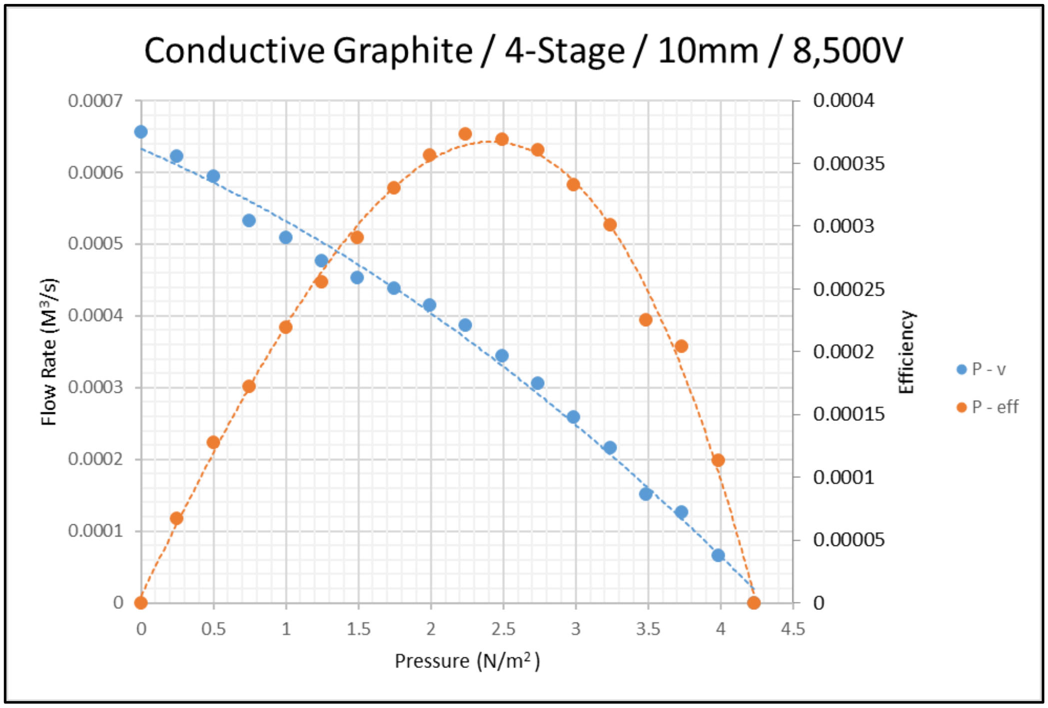


Figure A 56

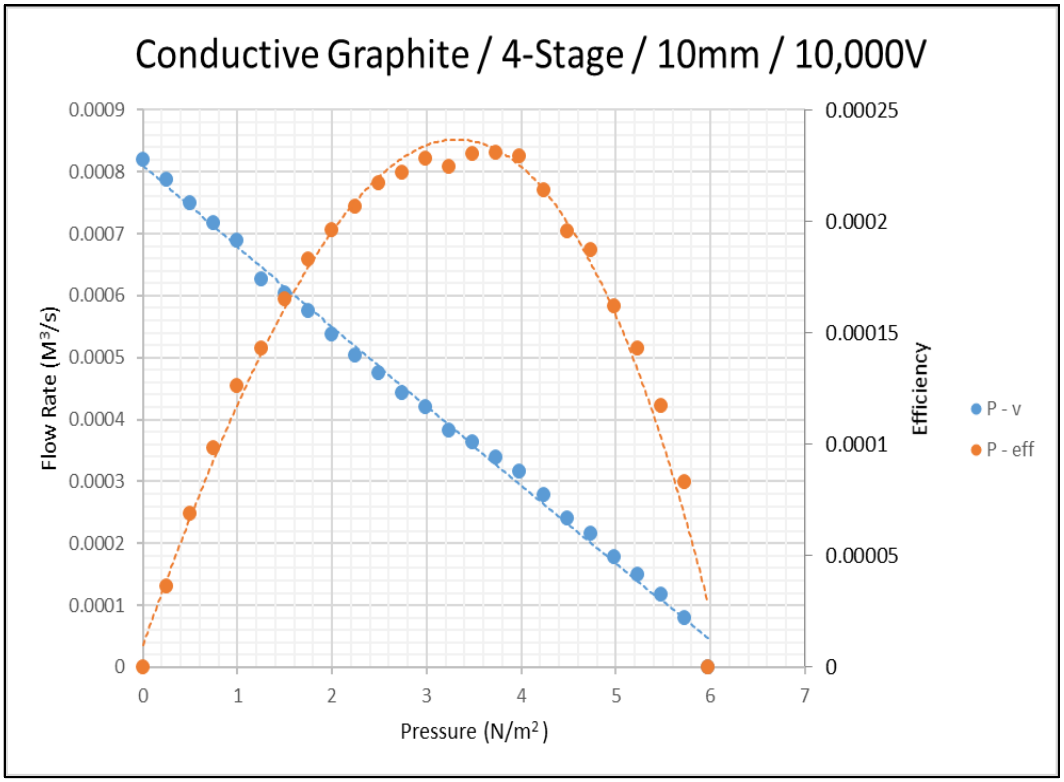


Figure A 57

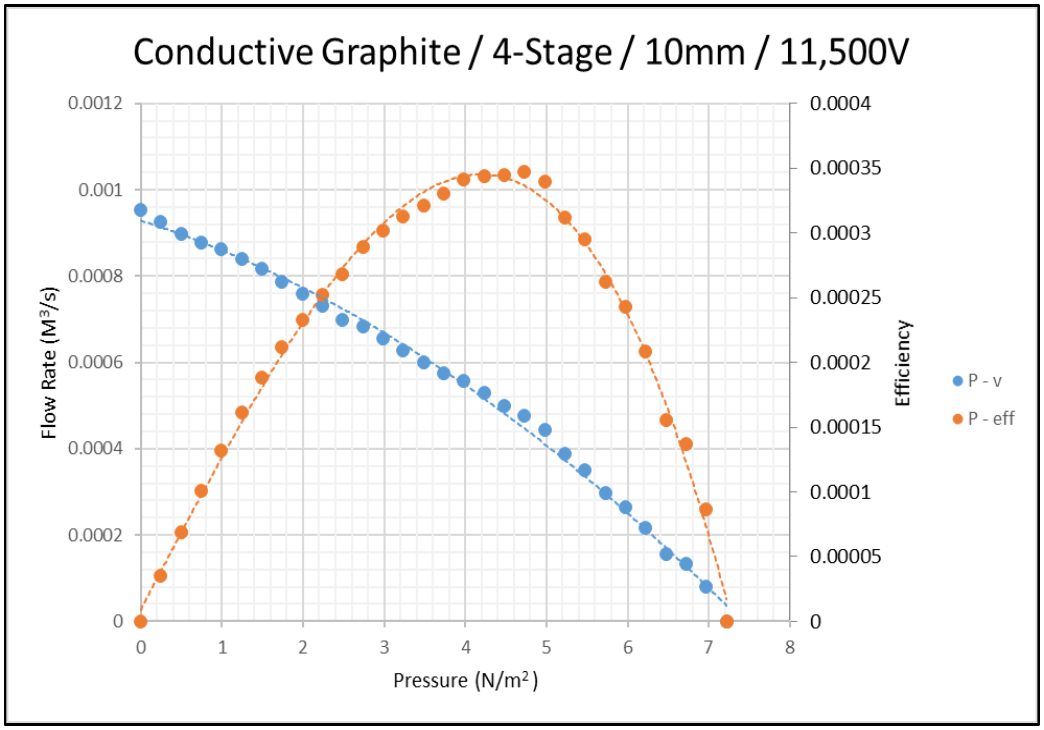


Figure A 58

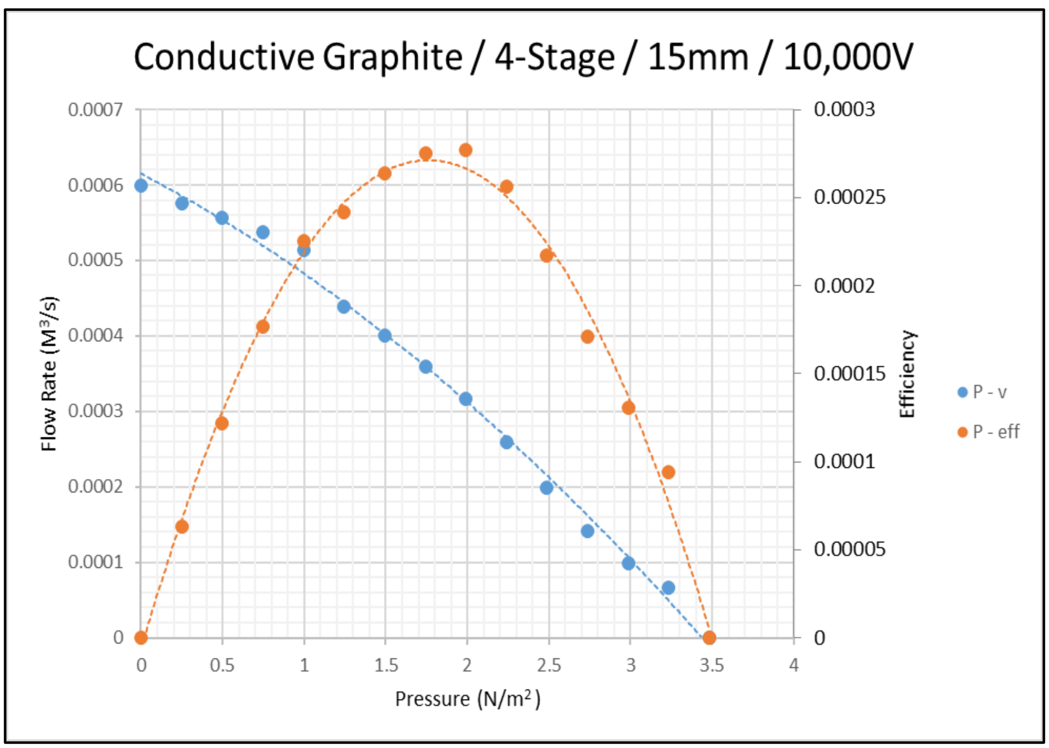


Figure A 59

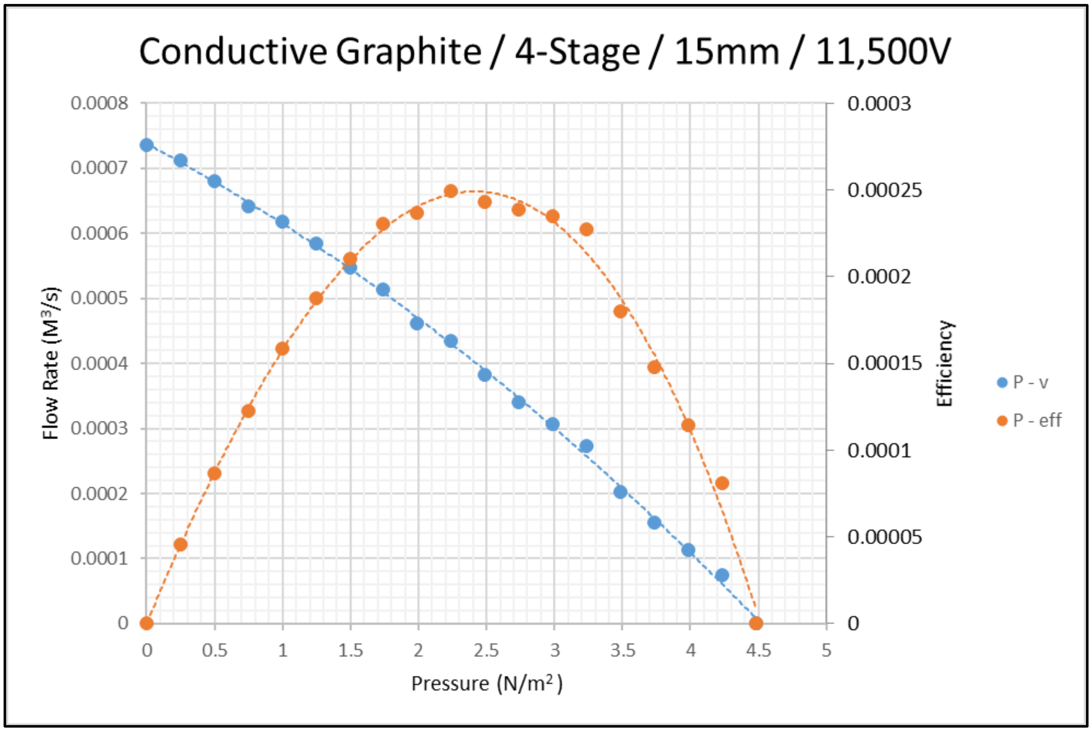


Figure A 60

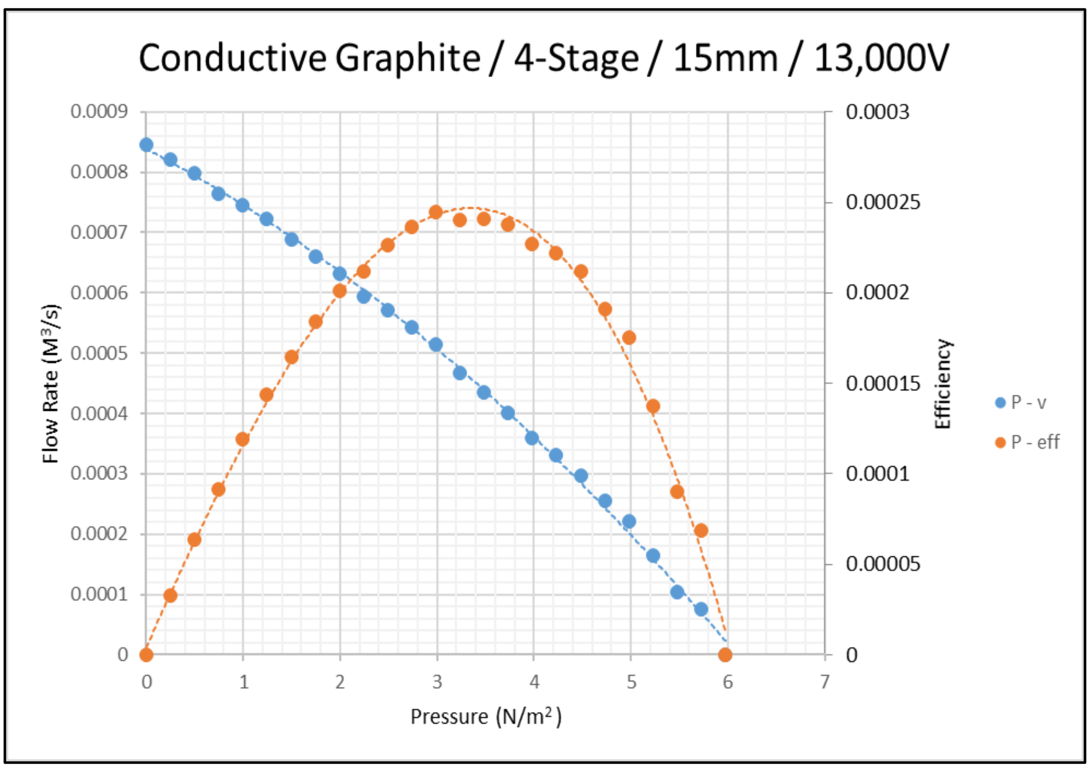


Figure A 61

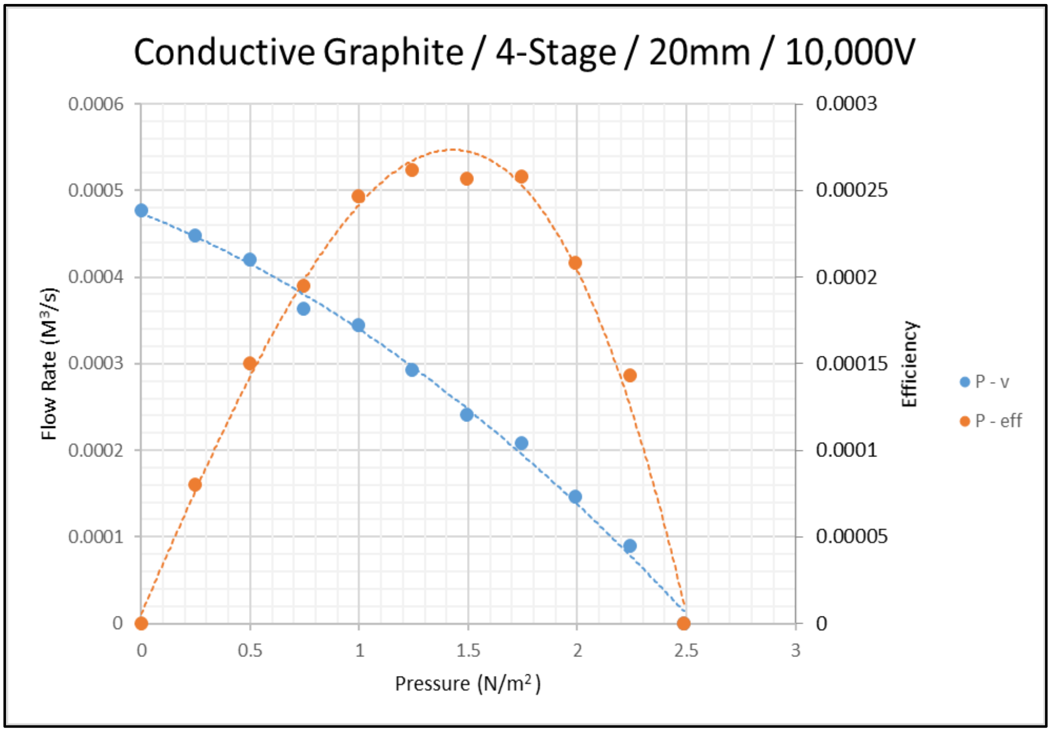


Figure A 62

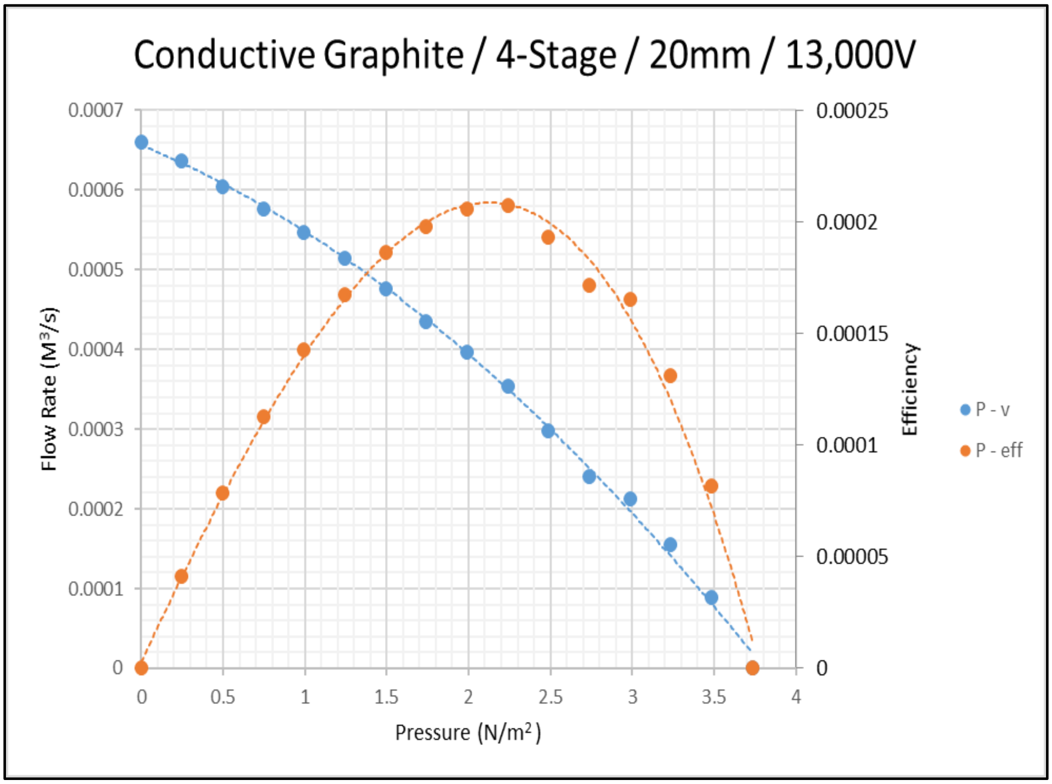


Figure A 63

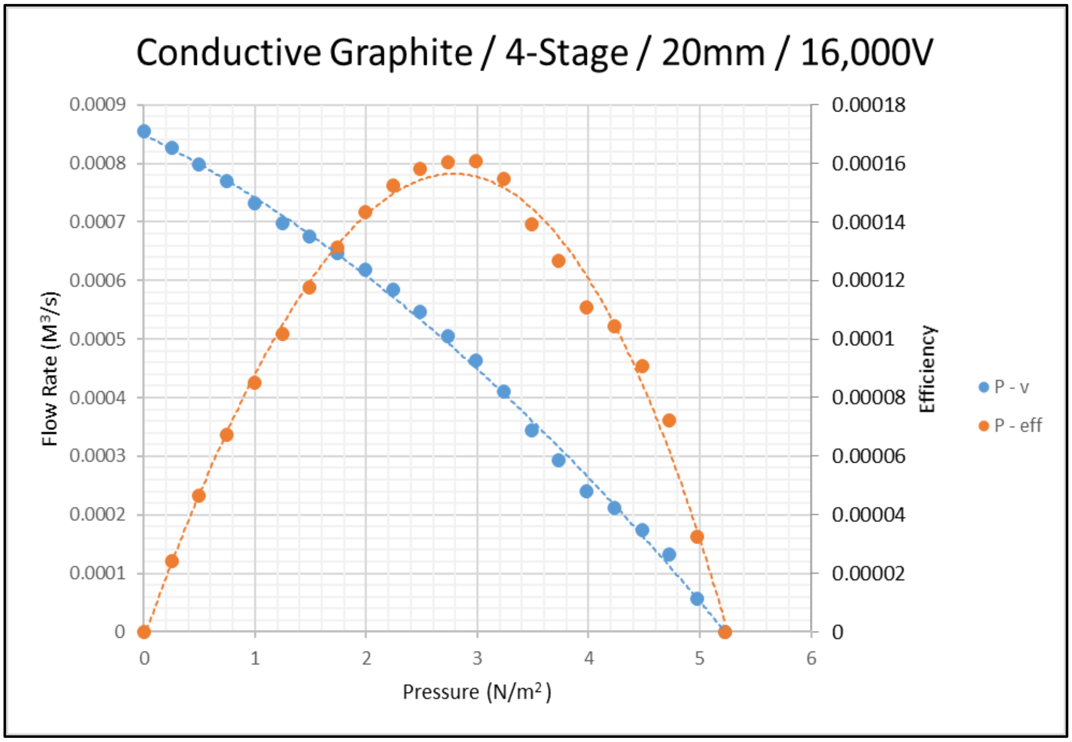


Figure A 64

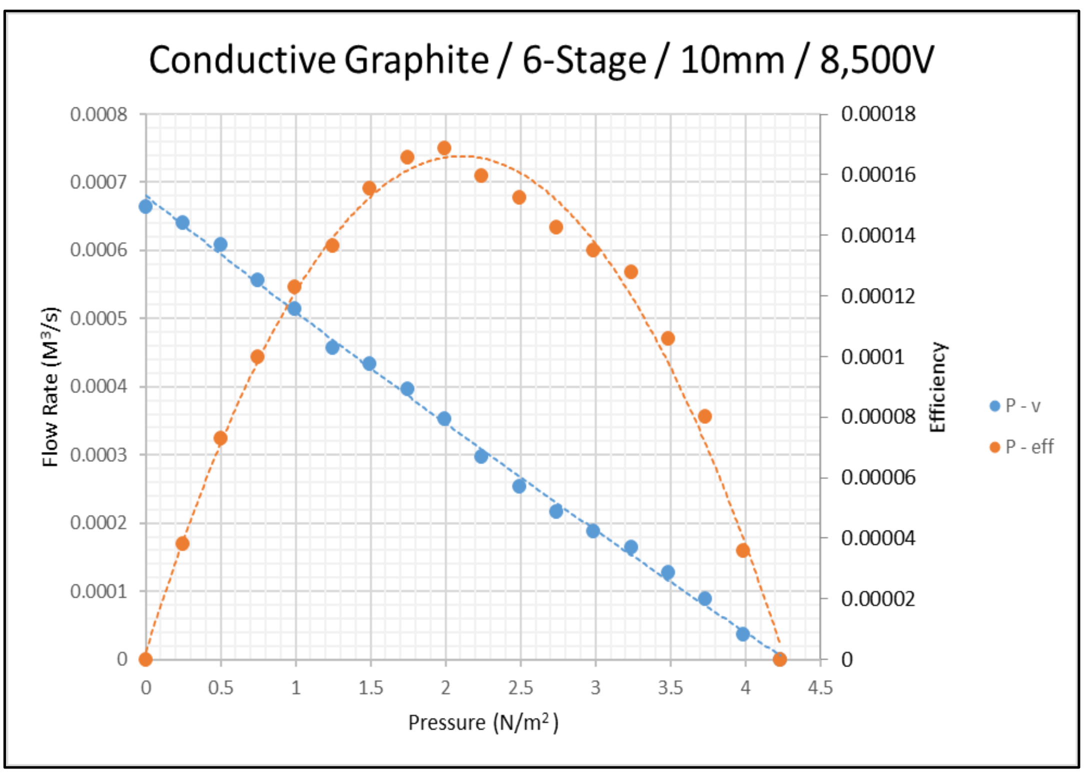


Figure A 65

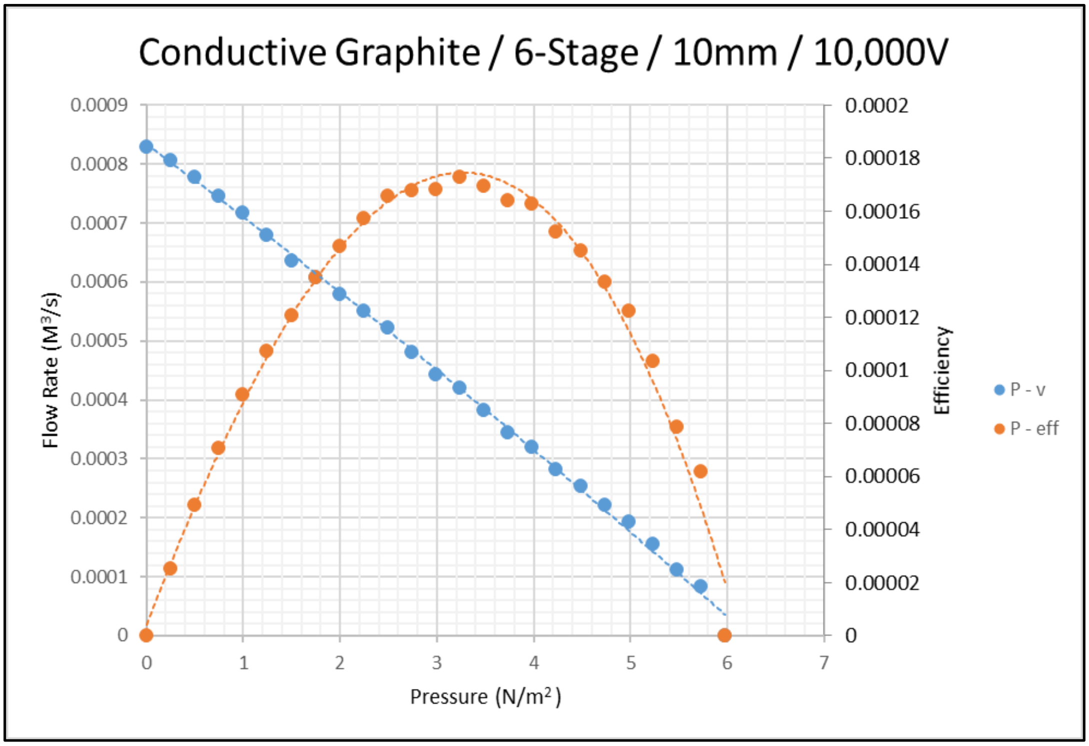


Figure A 66

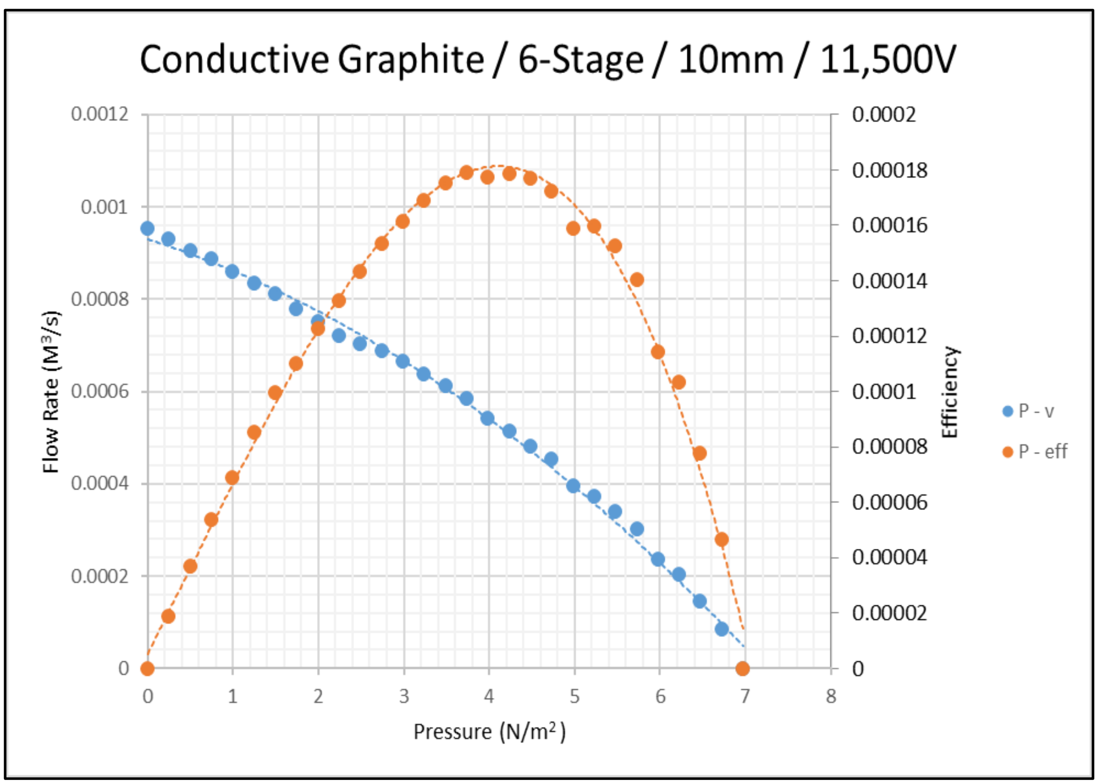


Figure A 67

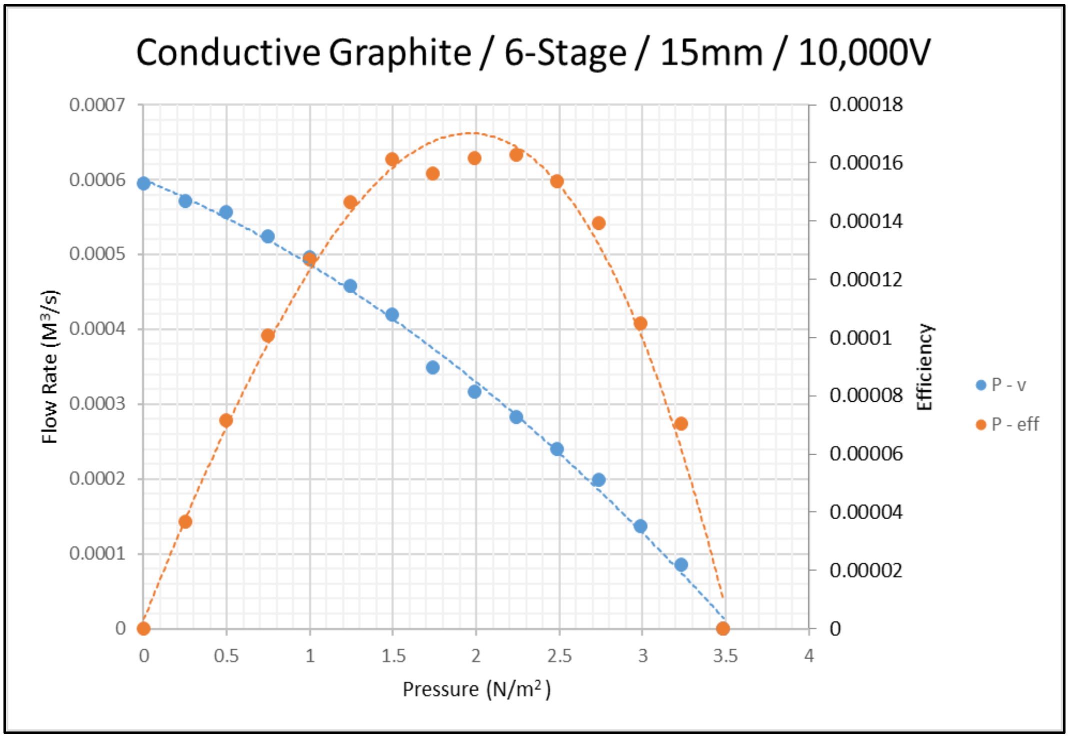


Figure A 68

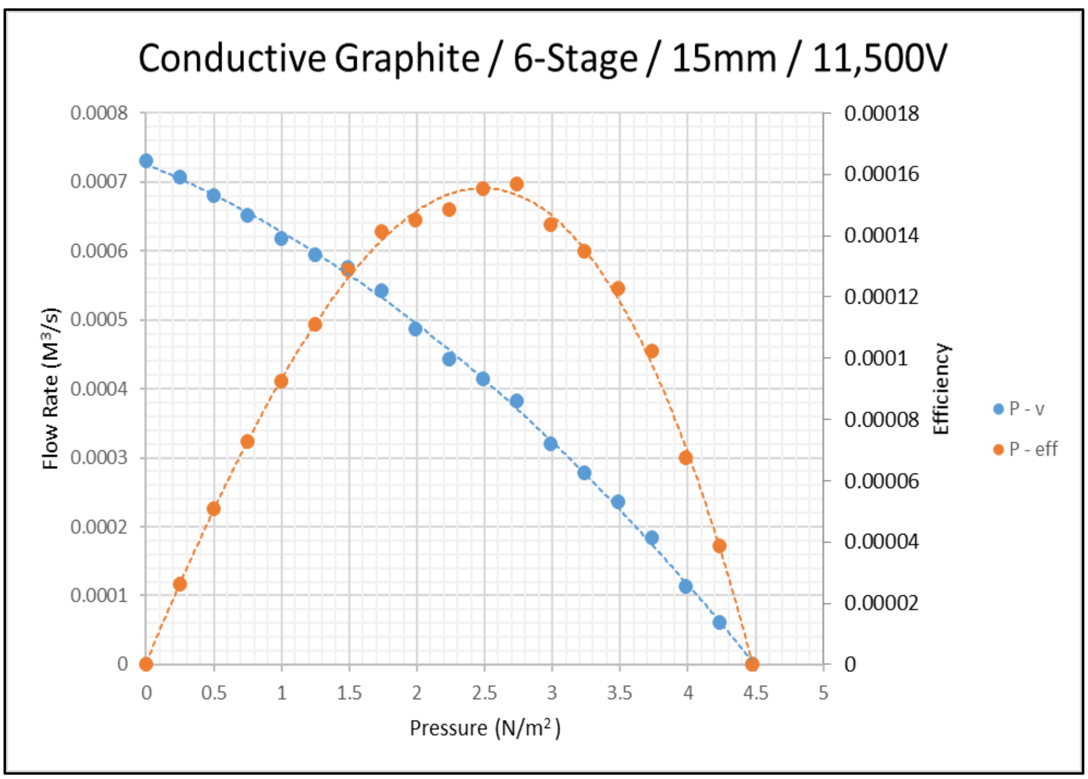


Figure A 69

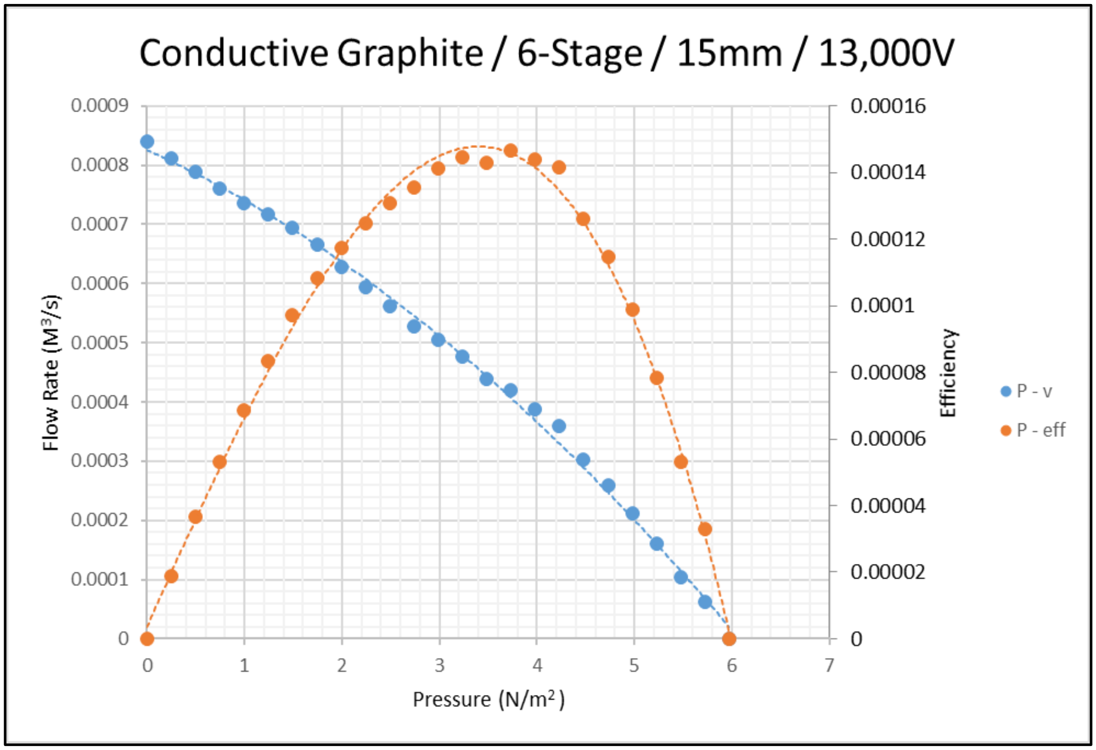


Figure A 70

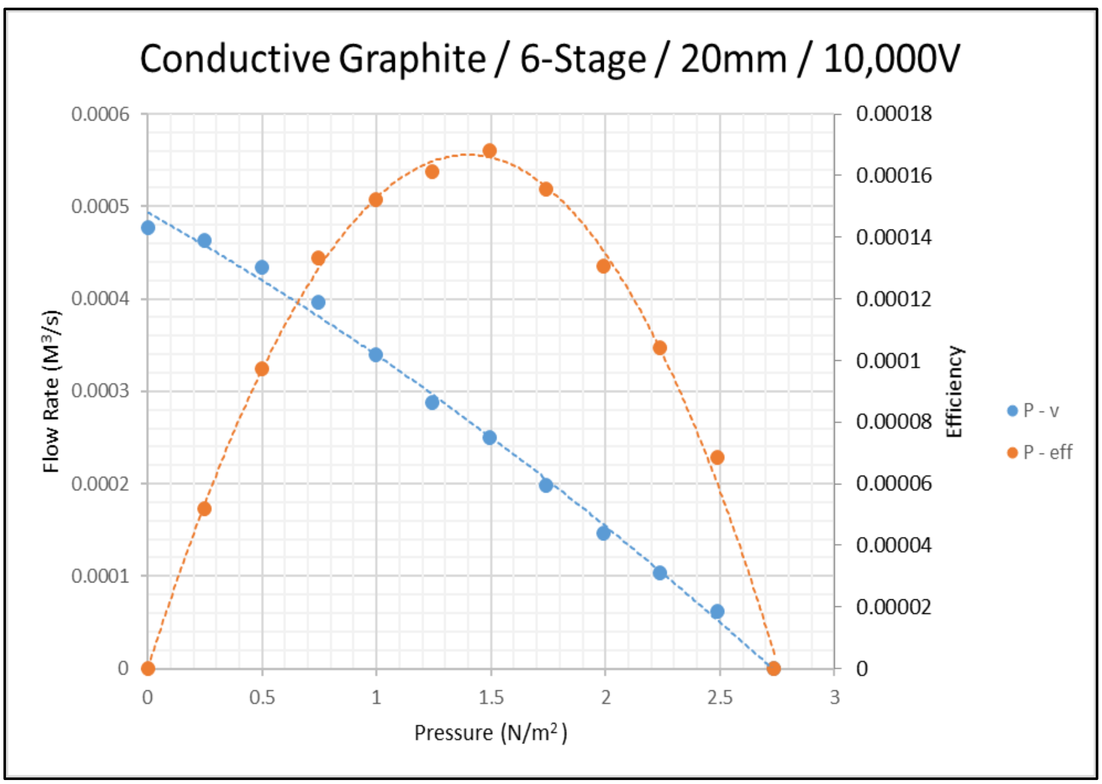


Figure A 71

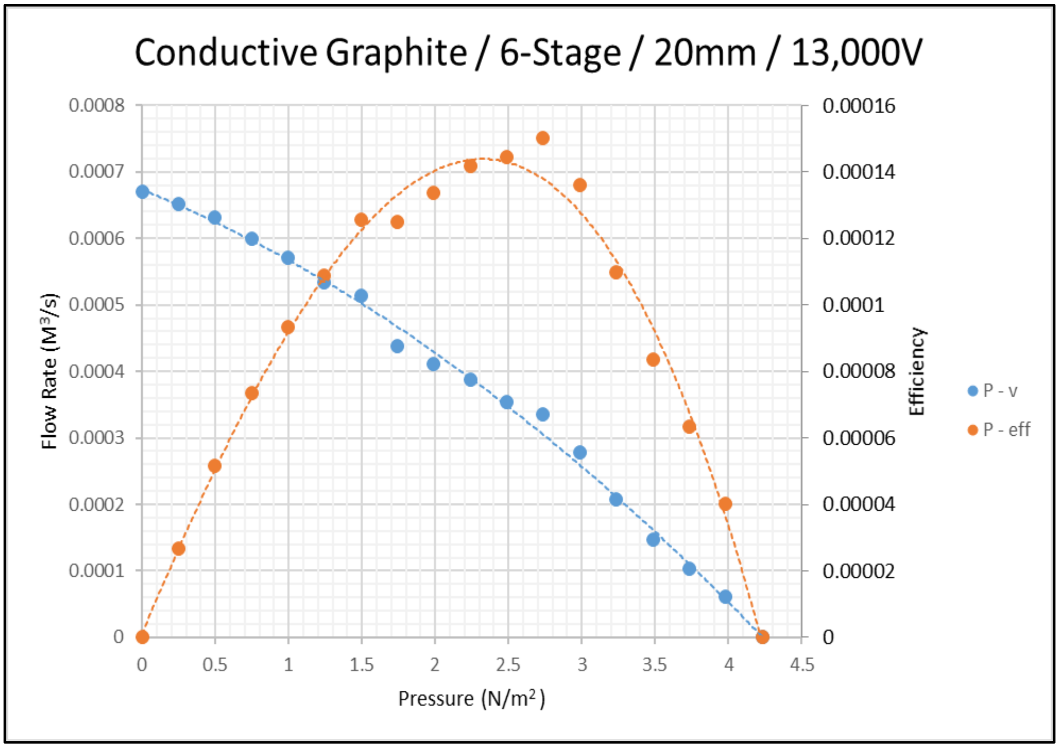


Figure A 72

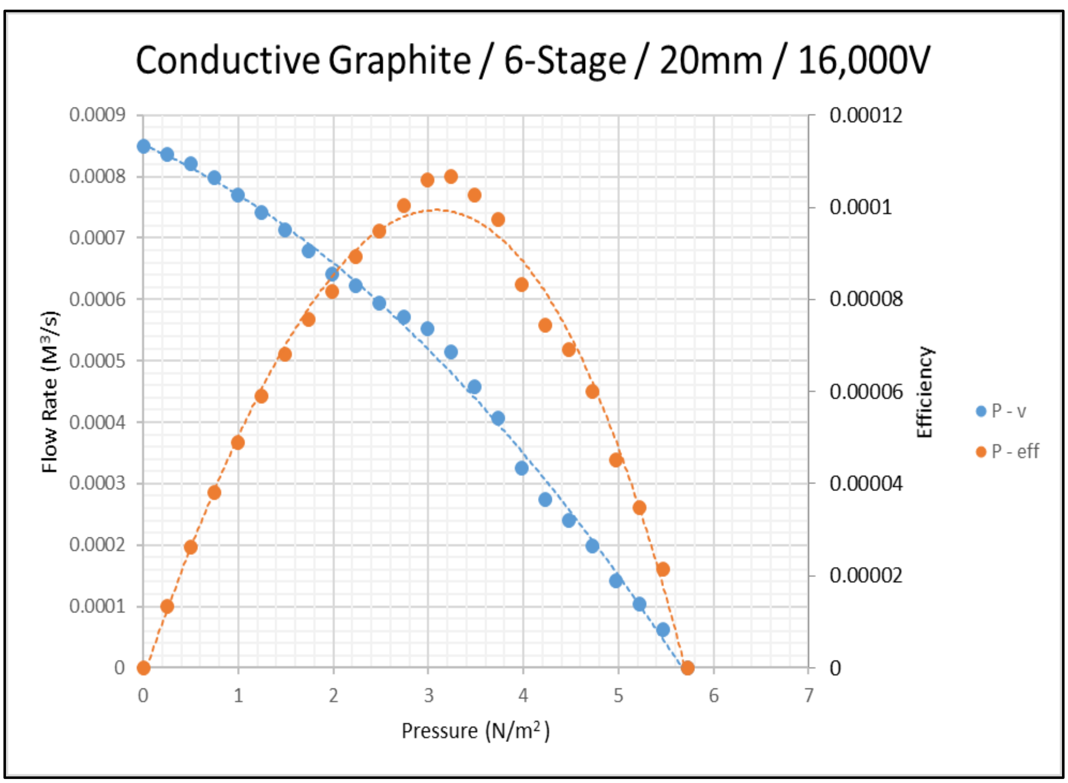


Figure A 73

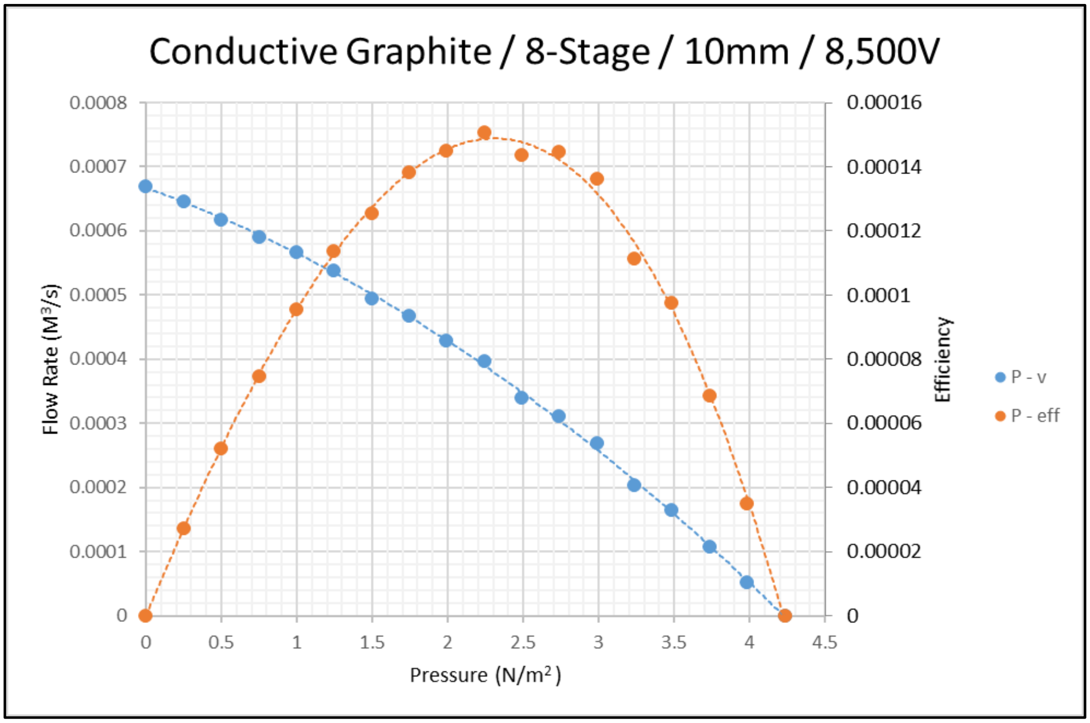


Figure A 74

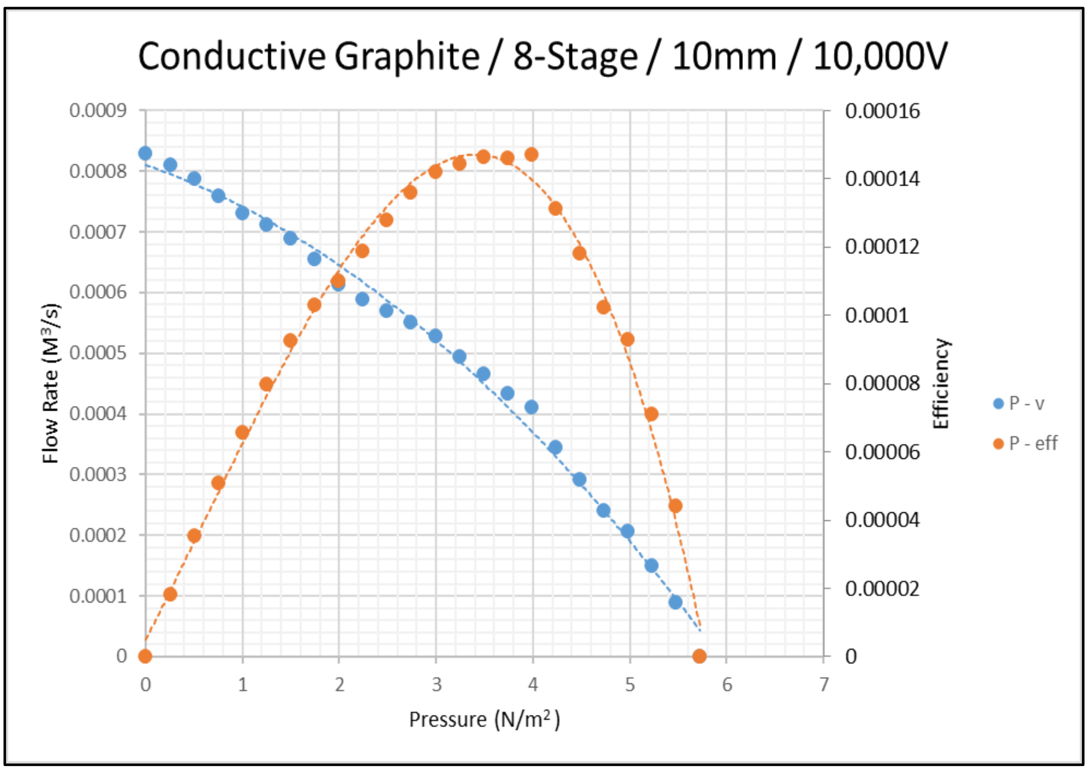


Figure A 75

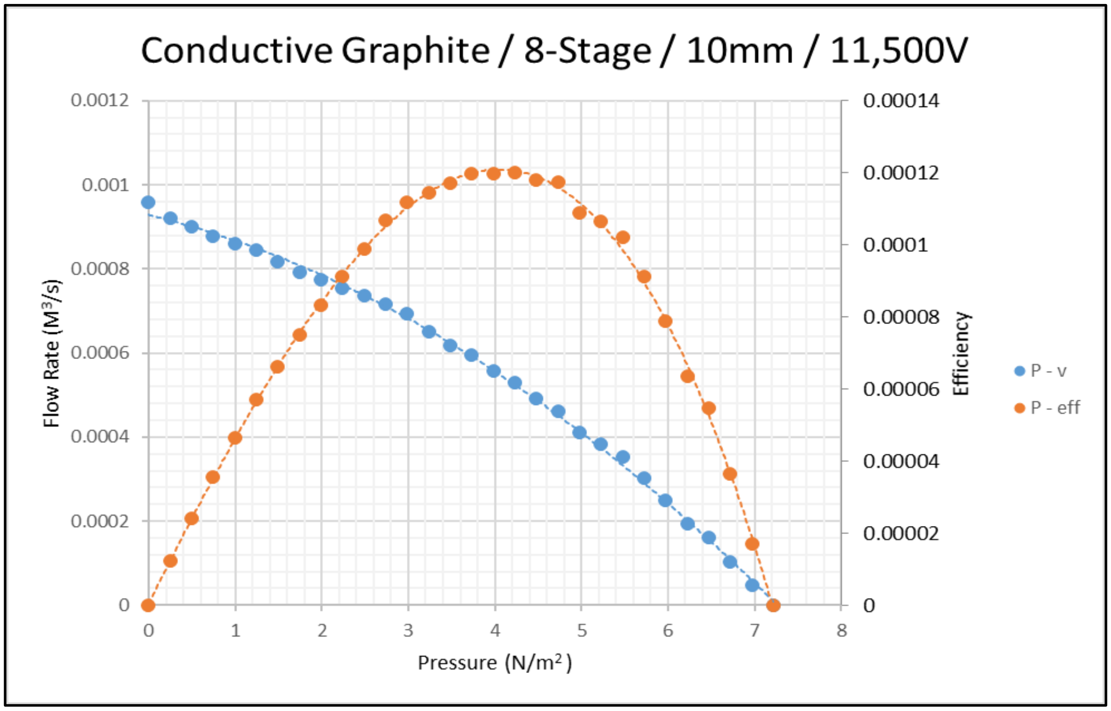


Figure A 76

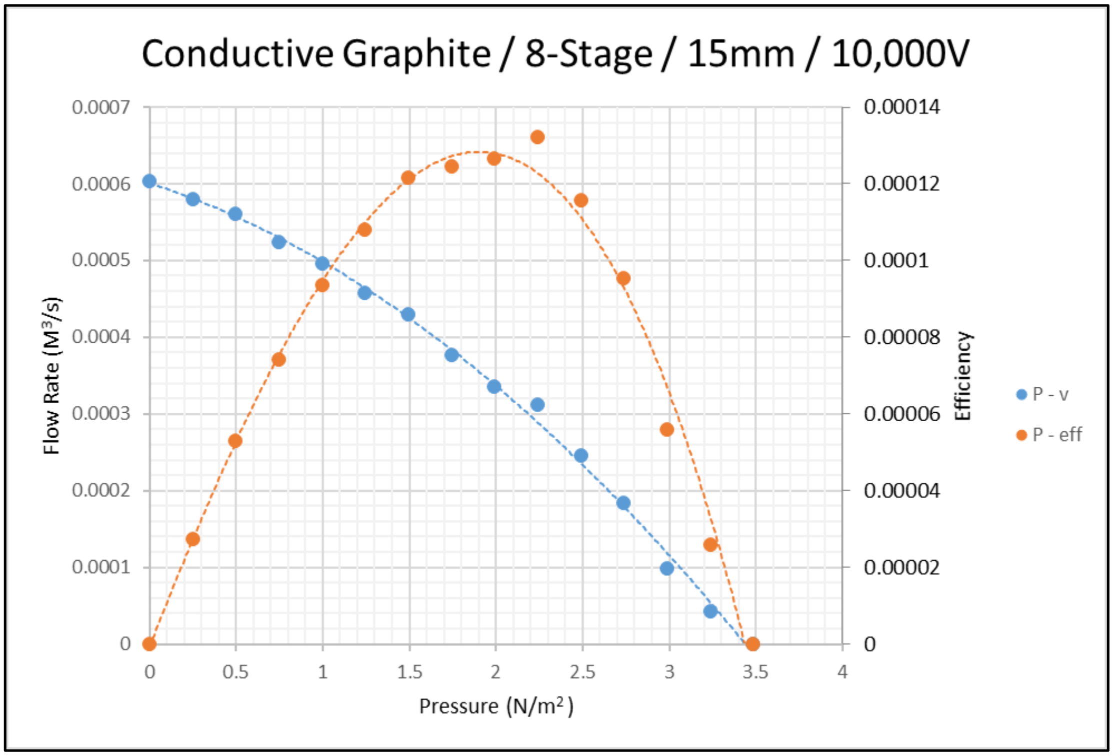


Figure A 77

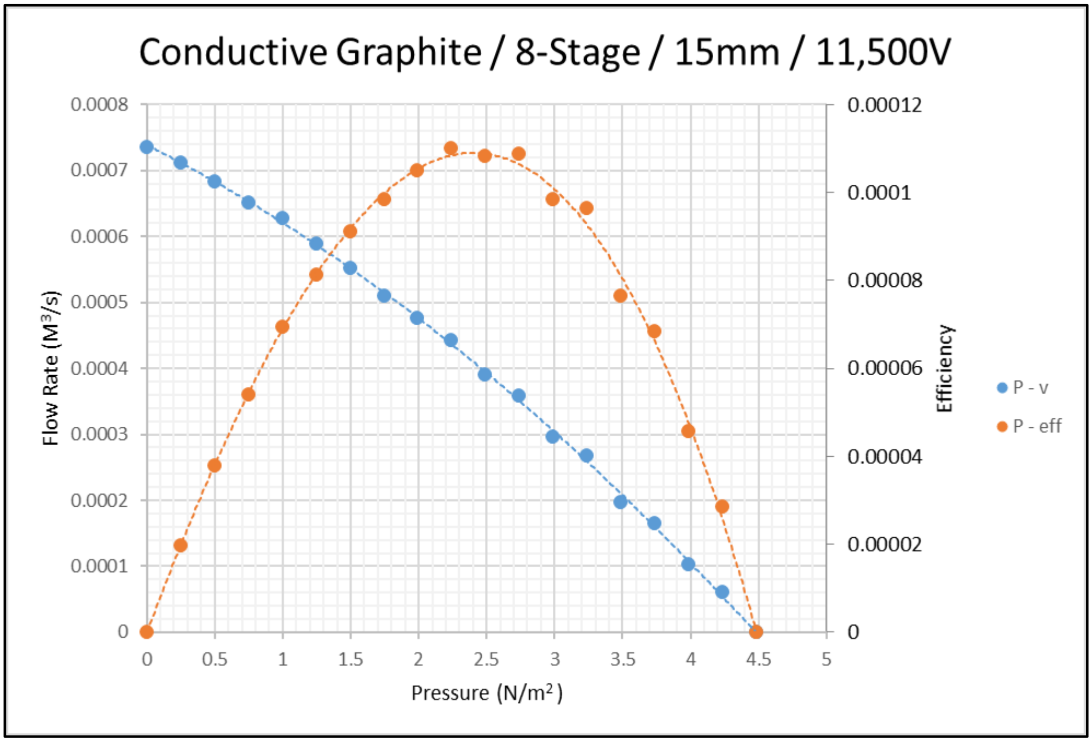


Figure A 78

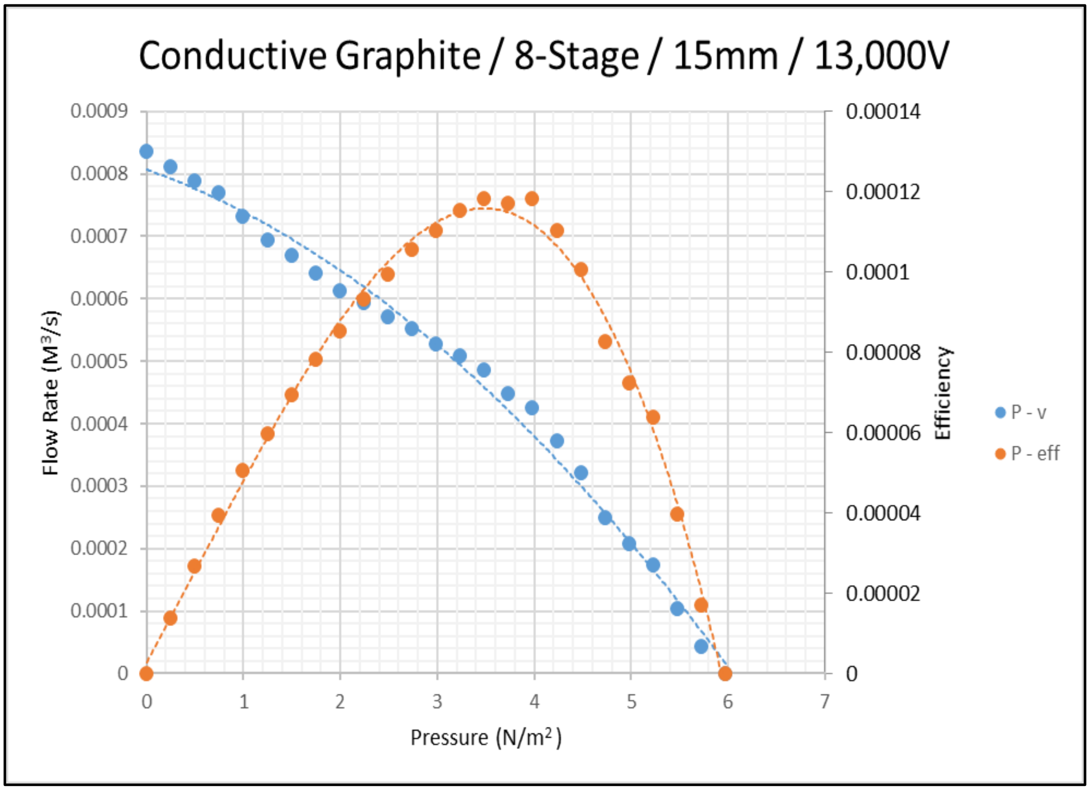


Figure A 79

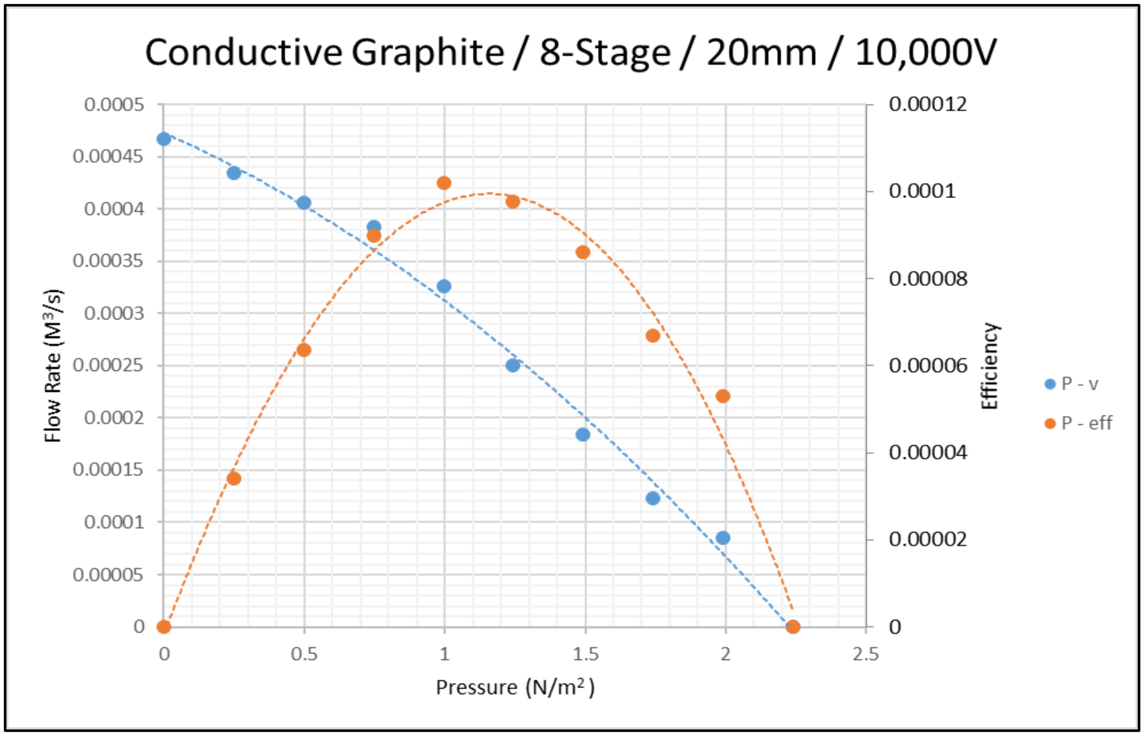


Figure A 80

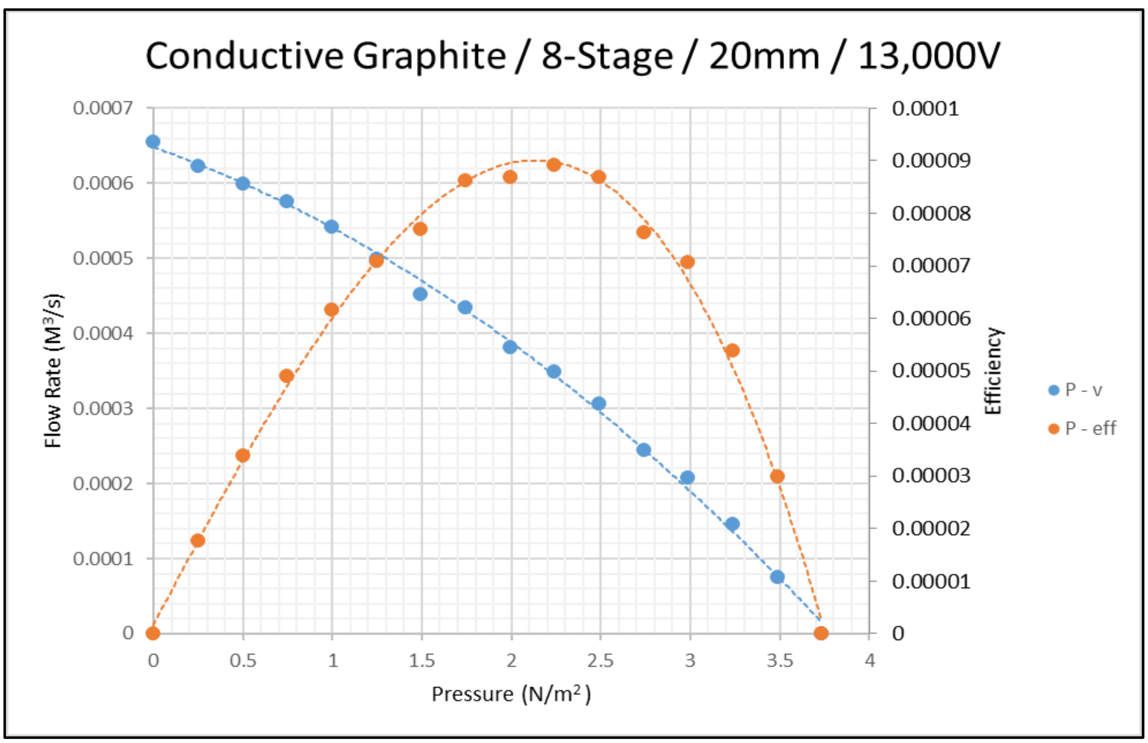
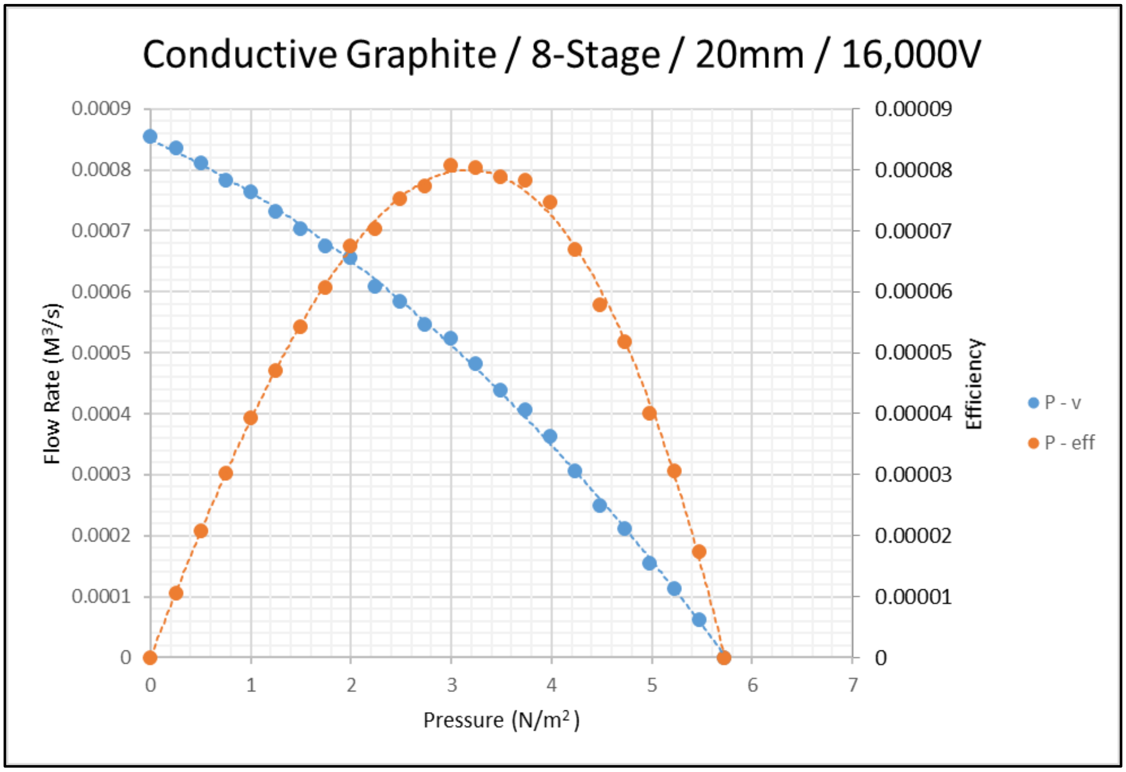


Figure A 81



Conductive Graphite / 8-Stage / 20mm / 16,000V
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
Flow Rate (M³/s)
0.00009
0.00008
0.00007
0.00006
0.00005
0.00004
0.00003
0.00002
0.00001
0
Efficiency
0
1
2
3
4
5
6
7
Pressure (N/m²)
P - v
P - eff

APPENDIX C

The following are the initial Minitab 2 factor 2 level DOE results.

General Factorial Regression: Response versus Material, Voltage (10mm)

Factor Information

Factor	Levels	Values
Material	2	Copper, Aluminum
Voltage	2	7500, 10000

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	1.13083	0.37694	983.33	0.000
Linear	2	1.12963	0.56482	1473.43	0.000
Material	1	0.01333	0.01333	34.78	0.000
Voltage	1	1.11630	1.11630	2912.09	0.000
2-Way Interactions	1	0.00120	0.00120	3.13	0.115
Material*Voltage	1	0.00120	0.00120	3.13	0.115
Error	8	0.00307	0.00038		
Total	11	1.13390			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0195789	99.73%	99.63%	99.39%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.36500	0.00565	241.51	0.000	
Material					
Copper	-0.03333	0.00565	-5.90	0.000	1.00
Aluminum	0.03333	0.00565	5.90	0.000	*
Voltage					
7500	-0.30500	0.00565	-53.96	0.000	1.00
10000	0.30500	0.00565	53.96	0.000	*
Material*Voltage					
Copper 7500	-0.01000	0.00565	-1.77	0.115	1.00
Copper 10000	0.01000	0.00565	1.77	0.115	*
Aluminum 7500	0.01000	0.00565	1.77	0.115	*
Aluminum 10000	-0.01000	0.00565	-1.77	0.115	*

Regression Equation

```
Response = 1.36500 - 0.03333 Material_Copper + 0.03333 Material_Aluminum
           - 0.30500 Voltage_7500 + 0.30500 Voltage_10000 -
 0.01000 Material*Voltage_Copper
           7500 + 0.01000 Material*Voltage_Copper 10000
+ 0.01000 Material*Voltage_Aluminum
           7500 - 0.01000 Material*Voltage_Aluminum 10000
```

General Factorial Regression: Response versus Shape, Voltage (10mm)

Factor Information

Factor	Levels	Values
Shape	2	Cylindrical, Conical
Voltage	2	11000, 13000

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	1.02407	0.341356	1050.32	0.000
Linear	2	1.02243	0.511217	1572.97	0.000
Shape	1	0.25230	0.252300	776.31	0.000
Voltage	1	0.77013	0.770133	2369.64	0.000
2-Way Interactions	1	0.00163	0.001633	5.03	0.055
Shape*Voltage	1	0.00163	0.001633	5.03	0.055
Error	8	0.00260	0.000325		
Total	11	1.02667			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0180278	99.75%	99.65%	99.43%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	2.17667	0.00520	418.25	0.000	
Shape					
Cylindrical	-0.14500	0.00520	-27.86	0.000	1.00
Conical	0.14500	0.00520	27.86	0.000	*
Voltage					
11000	-0.25333	0.00520	-48.68	0.000	1.00
13000	0.25333	0.00520	48.68	0.000	*
Shape*Voltage					
Cylindrical 11000	-0.01167	0.00520	-2.24	0.055	1.00
Cylindrical 13000	0.01167	0.00520	2.24	0.055	*
Conical 11000	0.01167	0.00520	2.24	0.055	*
Conical 13000	-0.01167	0.00520	-2.24	0.055	*

Regression Equation

```
Response = 2.17667 - 0.14500 Shape_Cylindrical + 0.14500 Shape_Conical
           - 0.25333 Voltage_11000 + 0.25333 Voltage_13000
           - 0.01167 Shape*Voltage_Cylindrical 11000
+ 0.01167 Shape*Voltage_Cylindrical
           13000 + 0.01167 Shape*Voltage_Conical 11000 - 0.01167 Shape*Voltage_Conical
13000
```

General Factorial Regression: Response versus Multi-Stage, Voltage (10mm)

Factor Information

Factor	Levels	Values
Multi-Stage	2	4-Stage, 8-Stage
Voltage	2	8500, 11500

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	1.12329	0.37443	898.63	0.000
Linear	2	1.12262	0.56131	1347.14	0.000
Multi-Stage	1	0.00021	0.00021	0.50	0.500
Voltage	1	1.12241	1.12241	2693.78	0.000
2-Way Interactions	1	0.00067	0.00067	1.62	0.239
Multi-Stage*Voltage	1	0.00067	0.00067	1.62	0.239
Error	8	0.00333	0.00042		
Total	11	1.12663			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0204124	99.70%	99.59%	99.33%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.69750	0.00589	288.08	0.000	
Multi-Stage					
4-Stage	-0.00417	0.00589	-0.71	0.500	1.00
8-Stage	0.00417	0.00589	0.71	0.500	*
Voltage					
8500	-0.30583	0.00589	-51.90	0.000	1.00
11500	0.30583	0.00589	51.90	0.000	*
Multi-Stage*Voltage					
4-Stage 8500	-0.00750	0.00589	-1.27	0.239	1.00
4-Stage 11500	0.00750	0.00589	1.27	0.239	*
8-Stage 8500	0.00750	0.00589	1.27	0.239	*
8-Stage 11500	-0.00750	0.00589	-1.27	0.239	*

Regression Equation

```
Response = 1.69750 - 0.00417 Multi-Stage_4-Stage + 0.00417 Multi-Stage_8-Stage
           - 0.30583 Voltage_8500 + 0.30583 Voltage_11500
           - 0.00750 Multi-Stage*Voltage_4-Stage 8500 + 0.00750 Multi-Stage*Voltage_4-
Stage
           11500 + 0.00750 Multi-Stage*Voltage_8-Stage 8500
           - 0.00750 Multi-Stage*Voltage_8-Stage 11500
```

General Factorial Regression: Response versus Material, Voltage (15mm)

Factor Information

Factor	Levels	Values
Material	2	Copper, Aluminum
Voltage	2	10000, 15000

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	2.42016	0.80672	3338.15	0.000
Linear	2	2.41995	1.20997	5006.79	0.000
Material	1	0.01687	0.01687	69.83	0.000
Voltage	1	2.40307	2.40307	9943.76	0.000
2-Way Interactions	1	0.00021	0.00021	0.86	0.380
Material*Voltage	1	0.00021	0.00021	0.86	0.380
Error	8	0.00193	0.00024		
Total	11	2.42209			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0155456	99.92%	99.89%	99.82%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.59083	0.00449	354.49	0.000	
Material					
Copper	-0.03750	0.00449	-8.36	0.000	1.00
Aluminum	0.03750	0.00449	8.36	0.000	*
Voltage					
10000	-0.44750	0.00449	-99.72	0.000	1.00
15000	0.44750	0.00449	99.72	0.000	*
Material*Voltage					
Copper 10000	0.00417	0.00449	0.93	0.380	1.00
Copper 15000	-0.00417	0.00449	-0.93	0.380	*
Aluminum 10000	-0.00417	0.00449	-0.93	0.380	*
Aluminum 15000	0.00417	0.00449	0.93	0.380	*

Regression Equation

```
Response = 1.59083 - 0.03750 Material_Copper + 0.03750 Material_Aluminum
           - 0.44750 Voltage_10000 + 0.44750 Voltage_15000
+ 0.00417 Material*Voltage_Copper
           10000 - 0.00417 Material*Voltage_Copper 15000 -
 0.00417 Material*Voltage_Aluminum
           10000 + 0.00417 Material*Voltage_Aluminum 15000
```

General Factorial Regression: Response versus Shape, Voltage (15mm)

```
Factor Information

Factor   Levels  Values
Shape         2  Cylindrical, Conical
Voltage       2  15000, 18000


Analysis of Variance

Source                DF   Adj SS    Adj MS  F-Value  P-Value
Model                  3  1.21047  0.403489  1008.72    0.000
  Linear               2  1.15713  0.578567  1446.42    0.000
    Shape              1  0.45630  0.456300  1140.75    0.000
    Voltage            1  0.70083  0.700833  1752.08    0.000
  2-Way Interactions   1  0.05333  0.053333   133.33    0.000
    Shape*Voltage      1  0.05333  0.053333   133.33    0.000
Error                  8  0.00320  0.000400
Total                 11  1.21367


Model Summary

   S    R-sq  R-sq(adj)  R-sq(pred)
0.02  99.74%     99.64%      99.41%


Coefficients

Term                    Coef  SE Coef  T-Value  P-Value   VIF
Constant             2.62333  0.00577   454.37    0.000
Shape
  Cylindrical       -0.19500  0.00577   -33.77    0.000  1.00
  Conical            0.19500  0.00577    33.77    0.000     *
Voltage
  15000             -0.24167  0.00577   -41.86    0.000  1.00
  18000              0.24167  0.00577    41.86    0.000     *
Shape*Voltage
  Cylindrical 15000   0.06667  0.00577    11.55    0.000  1.00
  Cylindrical 18000  -0.06667  0.00577   -11.55    0.000     *
  Conical 15000      -0.06667  0.00577   -11.55    0.000     *
  Conical 18000       0.06667  0.00577    11.55    0.000     *


Regression Equation

Response = 2.62333 - 0.19500 Shape_Cylindrical + 0.19500 Shape_Conical
           - 0.24167 Voltage_15000 + 0.24167 Voltage_18000
           + 0.06667 Shape*Voltage_Cylindrical 15000 -
 0.06667 Shape*Voltage_Cylindrical
           18000 - 0.06667 Shape*Voltage_Conical 15000 + 0.06667 Shape*Voltage_Conical
18000
```

General Factorial Regression: Response versus Multi-Stage, Voltage (15mm)

Factor Information

Factor	Levels	Values
Multi-Stage	2	4-Stage, 8-Stage
Voltage	2	10000, 13000

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	0.801667	0.267222	728.79	0.000
Linear	2	0.801367	0.400683	1092.77	0.000
Multi-Stage	1	0.000533	0.000533	1.45	0.262
Voltage	1	0.800833	0.800833	2184.09	0.000
2-Way Interactions	1	0.000300	0.000300	0.82	0.392
Multi-Stage*Voltage	1	0.000300	0.000300	0.82	0.392
Error	8	0.002933	0.000367		
Total	11	0.804600			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0191485	99.64%	99.50%	99.18%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.51000	0.00553	273.17	0.000	
Multi-Stage					
4-Stage	0.00667	0.00553	1.21	0.262	1.00
8-Stage	-0.00667	0.00553	-1.21	0.262	*
Voltage					
10000	-0.25833	0.00553	-46.73	0.000	1.00
13000	0.25833	0.00553	46.73	0.000	*
Multi-Stage*Voltage					
4-Stage 10000	-0.00500	0.00553	-0.90	0.392	1.00
4-Stage 13000	0.00500	0.00553	0.90	0.392	*
8-Stage 10000	0.00500	0.00553	0.90	0.392	*
8-Stage 13000	-0.00500	0.00553	-0.90	0.392	*

Regression Equation

```
Response = 1.51000 + 0.00667 Multi-Stage_4-Stage - 0.00667 Multi-Stage_8-Stage
           - 0.25833 Voltage_10000 + 0.25833 Voltage_13000
           - 0.00500 Multi-Stage*Voltage_4-Stage 10000 + 0.00500 Multi-
Stage*Voltage_4-Stage
           13000 + 0.00500 Multi-Stage*Voltage_8-Stage 10000
           - 0.00500 Multi-Stage*Voltage_8-Stage 13000
```

General Factorial Regression: Response versus Material, Voltage (20mm)

Factor Information

Factor	Levels	Values
Material	2	Copper, Aluminum
Voltage	2	10000, 17500

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	3.41448	1.13816	5103.85	0.000
Linear	2	3.41298	1.70649	7652.42	0.000
Material	1	0.16194	0.16194	726.17	0.000
Voltage	1	3.25104	3.25104	14578.67	0.000
2-Way Interactions	1	0.00150	0.00150	6.71	0.032
Material*Voltage	1	0.00150	0.00150	6.71	0.032
Error	8	0.00178	0.00022		
Total	11	3.41626			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0149332	99.95%	99.93%	99.88%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.44117	0.00431	334.31	0.000	
Material					
Copper	-0.11617	0.00431	-26.95	0.000	1.00
Aluminum	0.11617	0.00431	26.95	0.000	*
Voltage					
10000	-0.52050	0.00431	-120.74	0.000	1.00
17500	0.52050	0.00431	120.74	0.000	*
Material*Voltage					
Copper 10000	-0.01117	0.00431	-2.59	0.032	1.00
Copper 17500	0.01117	0.00431	2.59	0.032	*
Aluminum 10000	0.01117	0.00431	2.59	0.032	*
Aluminum 17500	-0.01117	0.00431	-2.59	0.032	*

Regression Equation

```
Response = 1.44117 - 0.11617 Material_Copper + 0.11617 Material_Aluminum
           - 0.52050 Voltage_10000 + 0.52050 Voltage_17500 -
 0.01117 Material*Voltage_Copper
           10000 + 0.01117 Material*Voltage_Copper 17500
+ 0.01117 Material*Voltage_Aluminum
           10000 - 0.01117 Material*Voltage_Aluminum 17500
```

General Factorial Regression: Response versus Shape, Voltage (20mm)

Factor Information

Factor	Levels	Values
Shape	2	Cylindrical, Conical
Voltage	2	17500, 20750

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	1.82337	0.60779	1519.47	0.000
Linear	2	1.80083	0.90042	2251.04	0.000
Shape	1	1.22880	1.22880	3072.00	0.000
Voltage	1	0.57203	0.57203	1430.08	0.000
2-Way Interactions	1	0.02253	0.02253	56.33	0.000
Shape*Voltage	1	0.02253	0.02253	56.33	0.000
Error	8	0.00320	0.00040		
Total	11	1.82657			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.02	99.82%	99.76%	99.61%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	2.55167	0.00577	441.96	0.000	
Shape					
Cylindrical	-0.32000	0.00577	-55.43	0.000	1.00
Conical	0.32000	0.00577	55.43	0.000	*
Voltage					
17500	-0.21833	0.00577	-37.82	0.000	1.00
20750	0.21833	0.00577	37.82	0.000	*
Shape*Voltage					
Cylindrical 17500	0.04333	0.00577	7.51	0.000	1.00
Cylindrical 20750	-0.04333	0.00577	-7.51	0.000	*
Conical 17500	-0.04333	0.00577	-7.51	0.000	*
Conical 20750	0.04333	0.00577	7.51	0.000	*

Regression Equation

```
Response = 2.55167 - 0.32000 Shape_Cylindrical + 0.32000 Shape_Conical
           - 0.21833 Voltage_17500 + 0.21833 Voltage_20750
           + 0.04333 Shape*Voltage_Cylindrical 17500 -
 0.04333 Shape*Voltage_Cylindrical
           20750 - 0.04333 Shape*Voltage_Conical 17500 + 0.04333 Shape*Voltage_Conical
20750
```

General Factorial Regression: Response versus Multi-Stage, Voltage (20mm)

Factor Information

Factor	Levels	Values
Multi-Stage	2	4-Stage, 8-Stage
Voltage	2	10000, 16000

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	1.92869	0.64290	2204.22	0.000
Linear	2	1.92868	0.96434	3306.31	0.000
Multi-Stage	1	0.00068	0.00068	2.31	0.167
Voltage	1	1.92801	1.92801	6610.31	0.000
2-Way Interactions	1	0.00001	0.00001	0.03	0.870
Multi-Stage*Voltage	1	0.00001	0.00001	0.03	0.870
Error	8	0.00233	0.00029		
Total	11	1.93103			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0170783	99.88%	99.83%	99.73%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.39250	0.00493	282.45	0.000	
Multi-Stage					
4-Stage	0.00750	0.00493	1.52	0.167	1.00
8-Stage	-0.00750	0.00493	-1.52	0.167	*
Voltage					
10000	-0.40083	0.00493	-81.30	0.000	1.00
16000	0.40083	0.00493	81.30	0.000	*
Multi-Stage*Voltage					
4-Stage 10000	0.00083	0.00493	0.17	0.870	1.00
4-Stage 16000	-0.00083	0.00493	-0.17	0.870	*
8-Stage 10000	-0.00083	0.00493	-0.17	0.870	*
8-Stage 16000	0.00083	0.00493	0.17	0.870	*

Regression Equation

```
Response = 1.39250 + 0.00750 Multi-Stage_4-Stage - 0.00750 Multi-Stage_8-Stage
           - 0.40083 Voltage_10000 + 0.40083 Voltage_16000
           + 0.00083 Multi-Stage*Voltage_4-Stage 10000 - 0.00083 Multi-
Stage*Voltage_4-Stage
           16000 - 0.00083 Multi-Stage*Voltage_8-Stage 10000
           + 0.00083 Multi-Stage*Voltage_8-Stage 16000
```

APPENDIX D

The following tables are the initial Microsoft Excel calculated 2 factor 2 level DOE results.

Determine the effects of material type, and voltage on air flow for an ionic air moving device at 10mm.

levels =2 Factors: k=2 Replicates: n=3

Factors: Factor A: Material; Low = **Copper**, High = **Aluminum**
Factor B: Voltage; Low = **7,500 V**, High = **10,000 V**

Orthogonal Matrix of Runs and Settings				Data for Responses for Each Replicate			
	A	B	AB	Run 1	Run 2	Run 3	Average
[1]	-1	-1	1	1.04	0.99	1.02	1.0167
a	1	-1	-1	1.12	1.08	1.11	1.1033
b	-1	1	-1	1.66	1.63	1.65	1.6467
ab	1	1	1	1.71	1.68	1.69	1.6933
					Grand Average		**1.3650**

	A	B	AB	Average
[1]	-1	-1	1	1.0167
a	1	-1	-1	1.1033
b	-1	1	-1	1.6467
ab	1	1	1	1.6933

	A	B	AB	Average
[1]	-1.0167	-1.0167	1.0167	1.0167
a	1.1033	-1.1033	-1.1033	1.1033
b	-1.6467	1.6467	-1.6467	1.6467
ab	1.6933	1.6933	1.6933	1.6933

Effect	0.06667	0.61	-0.02
Coefficients	0.03333	0.305	-0.01
Contrast	0.4	3.66	-0.12
SS	0.01333	1.1163	0.0012

SUMMARY ANOVA

SOURCE		*SS*	*df*	*MS*	*f*	*P-value*	
A		0.01333	1	0.01333	34.7826	**0.00036269**	***Significant***
B		1.11630	1	1.11630	2912.087	**1.5421E-11**	***Significant***
AB		0.0012	1	0.0012	3.1304	0.11480795	
ERROR		0.00307	8	0.00038			
TOTAL		1.1339	11				

Determine the effects of collector shape, and voltage on air flow for an ionic air moving device at 10mm.							
levels =2 Factors: k=2 Replicates: n=3							
Factors: Factor A: Shape; Low = **Cylindrical**, High = **Conical** Factor B: Voltage; Low = **11,000 V**, High = **13,000 V**							
Orthogonal Matrix of Runs and Settings				Data for Responses for Each Replicate			
	A	B	AB	Run 1	Run 2	Run 3	Average
[1]	-1	-1	1	1.79	1.75	1.76	1.7667
a	1	-1	-1	2.09	2.09	2.06	2.0800
b	-1	1	-1	2.31	2.29	2.29	2.2967
ab	1	1	1	2.58	2.54	2.57	2.5633
					Grand Average		**2.1767**

	A	B	AB	Average
[1]	-1	-1	1	1.7667
a	1	-1	-1	2.0800
b	-1	1	-1	2.2967
ab	1	1	1	2.5633

	A	B	AB	Average
[1]	-1.7667	-1.7667	1.7667	1.7667
a	2.0800	-2.0800	-2.0800	2.0800
b	-2.2967	2.2967	-2.2967	2.2967
ab	2.5633	2.5633	2.5633	2.5633

Effect	0.29	0.50667	-0.02333
Coefficients	0.145	0.253	-0.0117
Contrast	1.74	3.04	-0.14
SS	0.25230	0.77013	0.001633

SUMMARY ANOVA

SOURCE		*SS*	*df*	*MS*	*f*	*P-value*	
A		0.25230	1	0.25230	776.3077	**2.972E-09**	***Significant***
B		0.77013	1	0.77013	2369.641	**3.5093E-11**	***Significant***
AB		0.001633	1	0.00163333	5.0256	0.0552705	
ERROR		0.00260	8	0.00032			
TOTAL		1.02667	11				

Determine the effects of multi-stage collectors, and voltage on air flow for an ionic air moving device at 10mm.

levels =2 Factors: k=2 Replicates: n=3

Factors: Factor A: Shape; Low = **4-Stage**, High = **8-Stage**
Factor B: Voltage; Low = **8,500 V**, High = **11,500 V**

Orthogonal Matrix of Runs and Settings				Data for Responses for Each Replicate			
	A	B	AB	Run 1	Run 2	Run 3	Average
[1]	-1	-1	1	1.39	1.36	1.39	1.3800
a	1	-1	-1	1.42	1.38	1.41	1.4033
b	-1	1	-1	2.02	1.99	2.01	2.0067
ab	1	1	1	2.03	1.98	1.99	2.0000
					Grand Average		**1.6975**

	A	B	AB	Average
[1]	-1	-1	1	1.3800
a	1	-1	-1	1.4033
b	-1	1	-1	2.0067
ab	1	1	1	2.0000

	A	B	AB	Average
[1]	-1.3800	-1.3800	1.3800	1.3800
a	1.4033	-1.4033	-1.4033	1.4033
b	-2.0067	2.0067	-2.0067	2.0067
ab	2.0000	2.0000	2.0000	2.0000

	A	B	AB
Effect	0.01	0.61167	-0.01500
Coefficients	0.004	0.306	-0.0075
Contrast	0.05	3.67	-0.09
SS	0.00021	1.12241	0.000675

SUMMARY ANOVA

SOURCE		*SS*	*df*	*MS*	*f*	*P-value*	
A		0.00021	1	0.00021	0.5000	0.499575894	
B		1.12241	1	1.12241	2693.780	**2.10442E-11**	***Significant***
AB		0.000675	1	0.000675	1.6200	0.238833144	
ERROR		0.00333	8	0.00042			
TOTAL		1.12663	11				

Determine the effects of collector material, and voltage on air flow for an ionic air moving device at 15mm.

levels =2 Factors: k=2 Replicates: n=3

Factors: Factor A: Shape; Low = **Copper**, High = **Aluminum**
Factor B: Voltage; Low = **10,000 V**, High = **15,000 V**

Orthogonal Matrix of Runs and Settings				Data for Responses for Each Replicate			
	A	B	AB	Run 1	Run 2	Run 3	Average
[1]	-1	-1	1	1.12	1.12	1.09	1.1100
a	1	-1	-1	1.19	1.16	1.18	1.1767
b	-1	1	-1	2.01	1.99	1.99	1.9967
ab	1	1	1	2.09	2.06	2.09	2.0800
					Grand Average		**1.5908**

	A	B	AB	Average
[1]	-1	-1	1	1.1100
a	1	-1	-1	1.1767
b	-1	1	-1	1.9967
ab	1	1	1	2.0800

	A	B	AB	Average
[1]	-1.1100	-1.1100	1.1100	1.1100
a	1.1767	-1.1767	-1.1767	1.1767
b	-1.9967	1.9967	-1.9967	1.9967
ab	2.0800	2.0800	2.0800	2.0800

	A	B	AB
Effect	0.07	0.89500	0.00833
Coefficients	0.037	0.448	0.0042
Contrast	0.45	5.37	0.05
SS	0.01687	2.40308	0.000208

SUMMARY ANOVA

SOURCE		*SS*	*df*	*MS*	*f*	*P-value*	
A		0.01687	1	0.01688	69.8276	**3.18692E-05**	***Significant***
B		2.40308	1	2.40308	9943.759	**1.14224E-13**	***Significant***
AB		0.000208	1	0.000208333	0.8621	0.380321544	
ERROR		0.00193	8	0.00024			
TOTAL		2.42209	11				

Determine the effects of collector shape, and voltage on air flow for an ionic air moving device at 15mm.

levels =2 Factors: k=2 Replicates: n=3

Factors: Factor A: Shape; Low = **Cylindrical**, High = **Conical**
Factor B: Voltage; Low = **15,000 V**, High = **18,000 V**

Orthogonal Matrix of Runs and Settings				Data for Responses for Each Replicate			
	A	B	AB	Run 1	Run 2	Run 3	Average
[1]	-1	-1	1	2.27	2.23	2.26	2.2533
a	1	-1	-1	2.52	2.52	2.49	2.5100
b	-1	1	-1	2.62	2.61	2.58	2.6033
ab	1	1	1	3.15	3.11	3.12	3.1267
					Grand Average		**2.6233**

	A	B	AB	Average
[1]	-1	-1	1	2.2533
a	1	-1	-1	2.5100
b	-1	1	-1	2.6033
ab	1	1	1	3.1267

	A	B	AB	Average
[1]	-2.2533	-2.2533	2.2533	2.2533
a	2.5100	-2.5100	-2.5100	2.5100
b	-2.6033	2.6033	-2.6033	2.6033
ab	3.1267	3.1267	3.1267	3.1267

Effect	0.39	0.48333	0.13333
Coefficients	0.195	0.242	0.0667
Contrast	2.34	2.90	0.80
SS	0.45630	0.70083	0.053333

SUMMARY ANOVA

SOURCE		*SS*	*df*	*MS*	*f*	*P-value*	
A		0.45630	1	0.45630	1140.7500	**6.44955E-10**	***Significant***
B		0.70083	1	0.70083	1752.083	**1.16917E-10**	***Significant***
AB		0.053333	1	0.053333333	133.3333	**2.87288E-06**	***Significant***
ERROR		0.00320	8	0.00040			
TOTAL		1.21367	11				

Determine the effects of multi-stage collectors, and voltage on air flow for an ionic air moving device at 15mm.

levels =2 Factors: k=2 Replicates: n=3

Factors: Factor A: Shape; Low = **4-Stage**, High = **8-Stage**
Factor B: Voltage; Low = **10,000 V**, High = **13,000 V**

Orthogonal Matrix of Runs and Settings				Data for Responses for Each Replicate			
	A	B	AB	Run 1	Run 2	Run 3	Average
[1]	-1	-1	1	1.27	1.24	1.25	1.2533
a	1	-1	-1	1.28	1.22	1.25	1.2500
b	-1	1	-1	1.79	1.77	1.78	1.7800
ab	1	1	1	1.77	1.74	1.76	1.7567
					Grand Average		**1.5100**

	A	B	AB	Average
[1]	-1	-1	1	1.2533
a	1	-1	-1	1.2500
b	-1	1	-1	1.7800
ab	1	1	1	1.7567

	A	B	AB	Average
[1]	-1.2533	-1.2533	1.2533	1.2533
a	1.2500	-1.2500	-1.2500	1.2500
b	-1.7800	1.7800	-1.7800	1.7800
ab	1.7567	1.7567	1.7567	1.7567

Effect	-0.01	0.51667	-0.01000
Coefficients	-0.007	0.258	-0.0050
Contrast	-0.08	3.10	-0.06
SS	0.00053	0.80083	0.000300

SUMMARY ANOVA

SOURCE		*SS*	*df*	*MS*	*f*	*P-value*	
A		0.00053	1	0.00053	1.4545	0.26225475	
B		0.80083	1	0.80083	2184.091	**4.85757E-11**	***Significant***
AB		0.000300	1	0.0003	0.8182	0.392136976	
ERROR		0.00293	8	0.00037			
TOTAL		0.80460	11				

Determine the effects of collector material, and voltage on air flow for an ionic air moving device at 20mm.

levels =2 Factors: k=2 Replicates: n=3

Factors: Factor A: Shape; Low = **Copper**, High = **Aluminum**
Factor B: Voltage; Low = **10,000 V**, High = **17,500 V**

Orthogonal Matrix of Runs and Settings				Data for Responses for Each Replicate			
	A	B	AB	Run 1	Run 2	Run 3	Average
[1]	-1	-1	1	0.8	0.8	0.78	0.7933
a	1	-1	-1	1.064	1.05	1.03	1.0480
b	-1	1	-1	1.87	1.84	1.86	1.8567
ab	1	1	1	2.08	2.07	2.05	2.0667
					Grand Average		**1.4412**

	A	B	AB	Average
[1]	-1	-1	1	0.7933
a	1	-1	-1	1.0480
b	-1	1	-1	1.8567
ab	1	1	1	2.0667

	A	B	AB	Average
[1]	-0.7933	-0.7933	0.7933	0.7933
a	1.0480	-1.0480	-1.0480	1.0480
b	-1.8567	1.8567	-1.8567	1.8567
ab	2.0667	2.0667	2.0667	2.0667

Effect	0.23	1.04100	-0.02233
Coefficients	0.116	0.521	-0.0112
Contrast	1.39	6.25	-0.13
SS	0.16194	3.25104	0.001496

SUMMARY ANOVA

SOURCE		*SS*	*df*	*MS*	*f*	*P-value*	
A		0.16194	1	0.16194	726.1719	**3.87194E-09**	***Significant***
B		3.25104	1	3.25104	14578.668	**2.47451E-14**	***Significant***
AB		0.001496	1	0.001496333	6.7100	**0.03209466**	***Significant***
ERROR		0.00178	8	0.00022			
TOTAL		3.41626	11				

Determine the effects of collector material, and voltage on air flow for an ionic air moving device at 20mm.
levels =2 Factors: k=2 Replicates: n=3
Factors: Factor A: Shape; Low = **Cylindrical**, High = **Conical** Factor B: Voltage; Low = **17,500 V**, High = **20,750 V**

Orthogonal Matrix of Runs and Settings				Data for Responses for Each Replicate			
	A	B	AB	Run 1	Run 2	Run 3	Average
[1]	-1	-1	1	2.08	2.05	2.04	2.0567
a	1	-1	-1	2.63	2.59	2.61	2.6100
b	-1	1	-1	2.43	2.38	2.41	2.4067
ab	1	1	1	3.14	3.14	3.12	3.1333
					Grand Average		**2.5517**

	A	B	AB	Average
[1]	-1	-1	1	2.0567
a	1	-1	-1	2.6100
b	-1	1	-1	2.4067
ab	1	1	1	3.1333

	A	B	AB	Average
[1]	-2.0567	-2.0567	2.0567	2.0567
a	2.6100	-2.6100	-2.6100	2.6100
b	-2.4067	2.4067	-2.4067	2.4067
ab	3.1333	3.1333	3.1333	3.1333

Effect	0.64	0.43667	0.08667
Coefficients	0.320	0.218	0.0433
Contrast	3.84	2.62	0.52
SS	1.22880	0.57203	0.022533

SUMMARY ANOVA

SOURCE		*SS*	*df*	*MS*	*f*	*P-value*	
A		1.22880	1	1.22880	3072.0000	**1.24585E-11**	***Significant***
B		0.57203	1	0.57203	1430.083	**2.62452E-10**	***Significant***
AB		0.022533	1	0.022533333	56.3333	**6.89142E-05**	***Significant***
ERROR		0.00320	8	0.00040			
TOTAL		1.82657	11				

Determine the effects of collector material, and voltage on air flow for an ionic air moving device at 20mm.

levels =2 Factors: k=2 Replicates: n=3

Factors: Factor A: Shape; Low = **4-Stage**, High = **8-Stage**
Factor B: Voltage; Low = **10,000 V**, High = **16,000 V**

Orthogonal Matrix of Runs and Settings				Data for Responses for Each Replicate			
	A	B	AB	Run 1	Run 2	Run 3	Average
[1]	-1	-1	1	1.01	0.98	1.01	1.0000
a	1	-1	-1	0.99	0.99	0.97	0.9833
b	-1	1	-1	1.81	1.79	1.8	1.8000
ab	1	1	1	1.81	1.79	1.76	1.7867
					Grand Average		**1.3925**

	A	B	AB	Average
[1]	-1	-1	1	1.0000
a	1	-1	-1	0.9833
b	-1	1	-1	1.8000
ab	1	1	1	1.7867

	A	B	AB	Average
[1]	-1.0000	-1.0000	1.0000	1.0000
a	0.9833	-0.9833	-0.9833	0.9833
b	-1.8000	1.8000	-1.8000	1.8000
ab	1.7867	1.7867	1.7867	1.7867

Effect	-0.01	0.80167	0.00167
Coefficients	-0.007	0.401	0.0008
Contrast	-0.09	4.81	0.01
SS	0.00067	1.92801	0.000008

SUMMARY ANOVA

SOURCE		*SS*	*df*	*MS*	*f*	*P-value*	
A		0.00067	1	0.00068	2.3143	0.166683589	
B		1.92801	1	1.92801	6610.314	**5.84035E-13**	***Significant***
AB		0.000008	1	8.33333E-06	0.0286	0.869968096	
ERROR		0.00233	8	0.00029			
TOTAL		1.93103	11				

APPENDIX E

The following tables are the initial Microsoft Excel calculated 2 factor 2 level DOE results.

Anova: Two-Factor With Replication (Material Analysis @ 10mm)						
SUMMARY	Copper	Aluminum	Total			
7,500V						
Count	3	3	6			
Sum	3.05	3.31	6.36			
Average	1.016666667	1.103333333	1.06			
Variance	0.000633333	0.000433333	0.00268			
10,000V						
Count	3	3	6			
Sum	4.94	5.08	10.02			
Average	1.646666667	1.693333333	1.67			
Variance	0.000233333	0.000233333	0.00084			
Total						
Count	6	6				
Sum	7.99	8.39				
Average	1.331666667	1.398333333				
Variance	0.119416667	0.104696667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Voltage)	1.1163	1	1.1163	2912.086957	1.5421E-11	5.317655072
Columns (Material)	0.013333333	1	0.013333333	34.7826087	0.000362693	5.317655072
Interaction	0.0012	1	0.0012	3.130434783	0.114807948	5.317655072
Within	0.003066667	8	0.000383333			
Total	1.1339	11				

Anova: Two-Factor With Replication (Shape Analysis @ 10mm)						
SUMMARY	Cylindrical	Conical	Total			
11,000 V						
Count	3	3	6			
Sum	5.3	6.24	11.54			
Average	1.766666667	2.08	1.923333333			
Variance	0.000433333	0.0003	0.029746667			
13,000 V						
Count	3	3	6			
Sum	6.89	7.69	14.58			
Average	2.296666667	2.563333333	2.43			
Variance	0.000133333	0.000433333	0.02156			
Total						
Count	6	6				
Sum	12.19	13.93				
Average	2.031666667	2.321666667				
Variance	0.084496667	0.070376667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Voltage)	0.770133333	1	0.770133333	2369.641026	3.50928E-11	5.317655072
Columns (Shape)	0.2523	1	0.2523	776.3076923	2.97202E-09	5.317655072
Interaction	0.001633333	1	0.001633333	5.025641026	0.055270504	5.317655072
Within	0.0026	8	0.000325			
Total	1.026666667	11				

Anova: Two-Factor With Replication (Multi-Stage Analysis @ 10mm)						
SUMMARY	4-Stage	8-Stage	Total			
8,500 V						
Count	3	3	6			
Sum	4.14	4.21	8.35			
Average	1.38	1.403333333	1.391666667			
Variance	0.0003	0.000433333	0.000456667			
11,500 V						
Count	3	3	6			
Sum	6.02	6	12.02			
Average	2.006666667	2	2.003333333			
Variance	0.000233333	0.0007	0.000386667			
Total						
Count	6	6				
Sum	10.16	10.21				
Average	1.693333333	1.701666667				
Variance	0.118026667	0.107256667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Voltage)	1.122408333	1	1.122408333	2693.78	2.10442E-11	5.317655072
Columns (Number of Stages)	0.000208333	1	0.000208333	0.5	0.499575894	5.317655072
Interaction	0.000675	1	0.000675	1.62	0.238833144	5.317655072
Within	0.003333333	8	0.000416667			
Total	1.126625	11				

Anova: Two-Factor With Replication (Material Analysis @ 15mm)						
SUMMARY	Copper	Aluminum	Total			
10,000 V						
Count	3	3	6			
Sum	3.33	3.53	6.86			
Average	1.11	1.176666667	1.143333333			
Variance	0.0003	0.000233333	0.001546667			
15,000 V						
Count	3	3	6			
Sum	5.99	6.24	12.23			
Average	1.996666667	2.08	2.038333333			
Variance	0.000133333	0.0003	0.002256667			
Total						
Count	6	6				
Sum	9.32	9.77				
Average	1.553333333	1.628333333				
Variance	0.236026667	0.245016667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Voltage)	2.403075	1	2.403075	9943.758621	1.14224E-13	5.317655072
Columns (Material)	0.016875	1	0.016875	69.82758621	3.18692E-05	5.317655072
Interaction	0.000208333	1	0.000208333	0.862068966	0.380321544	5.317655072
Within	0.001933333	8	0.000241667			
Total	2.422091667	11				

Anova: Two-Factor With Replication (Shape Analysis @ 15mm)						
SUMMARY	Cylindrical	Conical	Total			
15,000 V						
Count	3	3	6			
Sum	6.76	7.53	14.29			
Average	2.253333333	2.51	2.381666667			
Variance	0.000433333	0.0003	0.020056667			
18,000 V						
Count	3	3	6			
Sum	7.81	9.38	17.19			
Average	2.603333333	3.126666667	2.865			
Variance	0.000433333	0.000433333	0.08251			
Total						
Count	6	6				
Sum	14.57	16.91				
Average	2.428333333	2.818333333				
Variance	0.037096667	0.114376667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Voltage)	0.700833333	1	0.700833333	1752.083333	1.16917E-10	5.317655072
Columns (Shape)	0.4563	1	0.4563	1140.75	6.44955E-10	5.317655072
Interaction	0.053333333	1	0.053333333	133.3333333	2.87288E-06	5.317655072
Within	0.0032	8	0.0004			
Total	1.213666667	11				

Anova: Two-Factor With Replication (Multi-Stage Analysis @15mm)						
SUMMARY	4-Stage	8-Stage	Total			
10,000 V						
Count	3	3	6			
Sum	3.76	3.75	7.51			
Average	1.253333333	1.25	1.251666667			
Variance	0.000233333	0.0009	0.000456667			
13,000 V						
Count	3	3	6			
Sum	5.34	5.27	10.61			
Average	1.78	1.756666667	1.768333333			
Variance	0.0001	0.000233333	0.000296667			
Total						
Count	6	6				
Sum	9.1	9.02				
Average	1.516666667	1.503333333				
Variance	0.083346667	0.077466667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Voltage)	0.800833333	1	0.800833333	2184.09091	4.85757E-11	5.317655072
Columns (Number of Stages)	0.000533333	1	0.000533333	1.45454545	0.26225475	5.317655072
Interaction	0.0003	1	0.0003	0.81818182	0.392136976	5.317655072
Within	0.002933333	8	0.000366667			
Total	0.8046	11				

Anova: Two-Factor With Replication (Material Analysis @ 20mm)						
SUMMARY	Copper	Aluminum	Total			
10,000 V						
Count	3	3	6			
Sum	2.38	3.144	5.524			
Average	0.793333333	1.048	0.920666667			
Variance	0.000133333	0.000292	0.019626667			
17,500 V						
Count	3	3	6			
Sum	5.57	6.2	11.77			
Average	1.856666667	2.066666667	1.961666667			
Variance	0.000233333	0.000233333	0.013416667			
Total						
Count	6	6				
Sum	7.95	9.344				
Average	1.325	1.557333333				
Variance	0.33935	0.311514667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Voltage)	3.251043	1	3.251043	14578.66816	2.47451E-14	5.317655072
Columns (Material)	0.161936333	1	0.161936333	726.1718984	3.87194E-09	5.317655072
Interaction	0.001496333	1	0.001496333	6.710014948	0.03209466	5.317655072
Within	0.001784	8	0.000223			
Total	3.416259667	11				

Anova: Two-Factor With Replication (Shape Analysis @ 20mm)						
SUMMARY	Cylindrical	Conical	Total			
17,500 V						
Count	3	3	6			
Sum	6.17	7.83	14			
Average	2.056666667	2.61	2.333333333			
Variance	0.000433333	0.0004	0.092186667			
20,750 V						
Count	3	3	6			
Sum	7.22	9.4	16.62			
Average	2.406666667	3.133333333	2.77			
Variance	0.000633333	0.000133333	0.15872			
Total						
Count	6	6				
Sum	13.39	17.23				
Average	2.231666667	2.871666667				
Variance	0.037176667	0.082376667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Voltage)	0.572033333	1	0.572033333	1430.083333	2.62452E-10	5.317655072
Columns (Shape)	1.2288	1	1.2288	3072	1.24585E-11	5.317655072
Interaction	0.022533333	1	0.022533333	56.33333333	6.89142E-05	5.317655072
Within	0.0032	8	0.0004			
Total	1.826566667	11				

Anova: Two-Factor With Replication (Multi-Stage Analysis @20mm)						
SUMMARY	4-Stage	8-Stage	Total			
10,000 V						
Count	3	3	6			
Sum	3	2.95	5.95			
Average	1	0.983333333	0.991666667			
Variance	0.0003	0.000133333	0.000256667			
16,000 V						
Count	3	3	6			
Sum	5.4	5.36	10.76			
Average	1.8	1.786666667	1.793333333			
Variance	0.0001	0.000633333	0.000346667			
Total						
Count	6	6				
Sum	8.4	8.31				
Average	1.4	1.385				
Variance	0.19216	0.19391				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Voltage)	1.928008333	1	1.928008333	6610.31429	5.84035E-13	5.317655072
Columns (Number of Stages)	0.000675	1	0.000675	2.31428571	0.166683589	5.317655072
Interaction	8.33333E-06	1	8.33333E-06	0.02857143	0.869968096	5.317655072
Within	0.002333333	8	0.000291667			
Total	1.931025	11				

APPENDIX F

The following are the secondary Minitab 2 factor 2 level DOE results.

Multilevel Factorial Design

```
Factors:      2     Replicates:     3
Base runs:    4     Total runs:    12
Base blocks:  1     Total blocks:   1

Number of levels: 2, 2
```

General Factorial Regression: Response versus Material, Voltage (10mm)

```
Factor Information

Factor    Levels  Values
Material       2  Conductive Graphite, Aluminum
Voltage        2  7500, 10000


Analysis of Variance

Source               DF   Adj SS   Adj MS  F-Value  P-Value
Model                 3  1.24437  0.41479  1367.07    0.000
  Linear              2  1.23642  0.61821  2037.49    0.000
    Material          1  0.00185  0.00185     6.10    0.039
    Voltage           1  1.23457  1.23457  4068.88    0.000
  2-Way Interactions  1  0.00796  0.00796    26.22    0.001
    Material*Voltage  1  0.00796  0.00796    26.22    0.001
Error                 8  0.00243  0.00030
Total                11  1.24680

Model Summary

        S    R-sq  R-sq(adj)  R-sq(pred)
0.0174189  99.81%     99.73%      99.56%

Coefficients

Term                            Coef  SE Coef  T-Value  P-Value   VIF
Constant                     1.38592  0.00503   275.62    0.000
Material
  Conductive Graphite       -0.01242  0.00503    -2.47    0.039  1.00
Voltage
  7500                      -0.32075  0.00503   -63.79    0.000  1.00
Material*Voltage
  Conductive Graphite 7500  -0.02575  0.00503    -5.12    0.001  1.00

Regression Equation

Response = 1.38592 - 0.01242 Material_Conductive Graphite + 0.01242 Material_Aluminum
           - 0.32075 Voltage_7500 + 0.32075 Voltage_10000
           - 0.02575 Material*Voltage_Conductive Graphite 7500
           + 0.02575 Material*Voltage_Conductive Graphite 10000
           + 0.02575 Material*Voltage_Aluminum 7500 -
 0.02575 Material*Voltage_Aluminum 10000
```

Multilevel Factorial Design

```
Factors:      2     Replicates:     3
Base runs:    4     Total runs:    12
Base blocks:  1     Total blocks:   1

Number of levels: 2, 2
```

General Factorial Regression: Response versus Shape, Voltage (10mm)

```
Factor Information

Factor   Levels  Values
Shape         2  Parabolic, Conical
Voltage       2  11000, 13000


Analysis of Variance

Source                DF    Adj SS    Adj MS  F-Value  P-Value
Model                  3  0.813800  0.271267   757.02    0.000
  Linear               2  0.810467  0.405233  1130.88    0.000
    Shape              1  0.009633  0.009633    26.88    0.001
    Voltage            1  0.800833  0.800833  2234.88    0.000
  2-Way Interactions   1  0.003333  0.003333     9.30    0.016
    Shape*Voltage      1  0.003333  0.003333     9.30    0.016
Error                  8  0.002867  0.000358
Total                 11  0.816667


Model Summary

        S    R-sq  R-sq(adj)  R-sq(pred)
0.0189297  99.65%     99.52%      99.21%


Coefficients

Term                  Coef  SE Coef  T-Value  P-Value   VIF
Constant           2.29333  0.00546   419.68    0.000
Shape
  Parabolic       -0.02833  0.00546    -5.18    0.001  1.00
Voltage
  11000           -0.25833  0.00546   -47.27    0.000  1.00
Shape*Voltage
  Parabolic 11000  -0.01667  0.00546    -3.05    0.016  1.00


Regression Equation

Response = 2.29333 - 0.02833 Shape_Parabolic + 0.02833 Shape_Conical -
 0.25833 Voltage_11000
           + 0.25833 Voltage_13000 - 0.01667 Shape*Voltage_Parabolic 11000
           + 0.01667 Shape*Voltage_Parabolic 13000 + 0.01667 Shape*Voltage_Conical
11000
           - 0.01667 Shape*Voltage_Conical 13000
```

Multilevel Factorial Design

```
Factors:      2     Replicates:     3
Base runs:    4     Total runs:    12
Base blocks:  1     Total blocks:   1

Number of levels: 2, 2
```

General Factorial Regression: Response versus Material, Voltage (15mm)

Factor Information

Factor	Levels	Values
Material	2	Conductive Graphite, Aluminum
Voltage	2	10000, 15000

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	2.82257	0.94086	3421.29	0.000
Linear	2	2.81293	1.40647	5114.42	0.000
Material	1	0.04813	0.04813	175.03	0.000
Voltage	1	2.76480	2.76480	10053.82	0.000
2-Way Interactions	1	0.00963	0.00963	35.03	0.000
Material*Voltage	1	0.00963	0.00963	35.03	0.000
Error	8	0.00220	0.00027		
Total	11	2.82477			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0165831	99.92%	99.89%	99.82%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.69167	0.00479	353.38	0.000	
Material					
Conductive Graphite	0.06333	0.00479	13.23	0.000	1.00
Voltage					
10000	-0.48000	0.00479	-100.27	0.000	1.00
Material*Voltage					
Conductive Graphite 10000	-0.02833	0.00479	-5.92	0.000	1.00

Regression Equation

```
Response = 1.69167 + 0.06333 Material_Conductive Graphite - 0.06333 Material_Aluminum
           - 0.48000 Voltage_10000 + 0.48000 Voltage_15000
           - 0.02833 Material*Voltage_Conductive Graphite 10000
           + 0.02833 Material*Voltage_Conductive Graphite 15000
           + 0.02833 Material*Voltage_Aluminum 10000 -
 0.02833 Material*Voltage_Aluminum
           15000
```

Multilevel Factorial Design

Factors:	2	Replicates:	3
Base runs:	4	Total runs:	12
Base blocks:	1	Total blocks:	1

Number of levels: 2, 2

General Factorial Regression: Response versus Shape, Voltage (15mm)

Factor Information

Factor	Levels	Values
Shape	2	Parabolic, Conical
Voltage	2	15000, 18000

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	0.890358	0.296786	712.29	0.000
Linear	2	0.863283	0.431642	1035.94	0.000
Shape	1	0.046875	0.046875	112.50	0.000
Voltage	1	0.816408	0.816408	1959.38	0.000
2-Way Interactions	1	0.027075	0.027075	64.98	0.000
Shape*Voltage	1	0.027075	0.027075	64.98	0.000
Error	8	0.003333	0.000417		
Total	11	0.893692			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0204124	99.63%	99.49%	99.16%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	2.75583	0.00589	467.68	0.000	
Shape					
Parabolic	-0.06250	0.00589	-10.61	0.000	1.00
Voltage					
15000	-0.26083	0.00589	-44.26	0.000	1.00
Shape*Voltage					
Parabolic 15000	0.04750	0.00589	8.06	0.000	1.00

Regression Equation

```
Response = 2.75583 - 0.06250 Shape_Parabolic + 0.06250 Shape_Conical -
 0.26083 Voltage_15000
           + 0.26083 Voltage_18000 + 0.04750 Shape*Voltage_Parabolic 15000
           - 0.04750 Shape*Voltage_Parabolic 18000 - 0.04750 Shape*Voltage_Conical
15000
           + 0.04750 Shape*Voltage_Conical 18000
```

Multilevel Factorial Design

Factors:	2	Replicates:	3
Base runs:	4	Total runs:	12
Base blocks:	1	Total blocks:	1

Number of levels: 2, 2

General Factorial Regression: Response versus Material, Voltage (20mm)

Factor Information

Factor	Levels	Values
Material	2	Conductive Graphite, Aluminum
Voltage	2	10000, 17500

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	3.66155	1.22052	5473.17	0.000
Linear	2	3.64203	1.82101	8165.99	0.000
Material	1	0.01643	0.01643	73.67	0.000
Voltage	1	3.62560	3.62560	16258.30	0.000
2-Way Interactions	1	0.01952	0.01952	87.54	0.000
Material*Voltage	1	0.01952	0.01952	87.54	0.000
Error	8	0.00178	0.00022		
Total	11	3.66333			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0149332	99.95%	99.93%	99.89%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.52033	0.00431	352.68	0.000	
Material					
Conductive Graphite	-0.03700	0.00431	-8.58	0.000	1.00
Voltage					
10000	-0.54967	0.00431	-127.51	0.000	1.00
Material*Voltage					
Conductive Graphite 10000	-0.04033	0.00431	-9.36	0.000	1.00

Regression Equation

```
Response = 1.52033 - 0.03700 Material_Conductive Graphite + 0.03700 Material_Aluminum
           - 0.54967 Voltage_10000 + 0.54967 Voltage_17500
           - 0.04033 Material*Voltage_Conductive Graphite 10000
           + 0.04033 Material*Voltage_Conductive Graphite 17500
           + 0.04033 Material*Voltage_Aluminum 10000 -
 0.04033 Material*Voltage_Aluminum
           17500
```

Multilevel Factorial Design

Factors:	2	Replicates:	3
Base runs:	4	Total runs:	12
Base blocks:	1	Total blocks:	1

Number of levels: 2, 2

General Factorial Regression: Response versus Shape, Voltage (20mm)

Factor Information

Factor	Levels	Values
Shape	2	Parabolic, Conical
Voltage	2	17500, 20750

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	1.08367	0.361222	1140.70	0.000
Linear	2	1.08353	0.541767	1710.84	0.000
Shape	1	0.24083	0.240833	760.53	0.000
Voltage	1	0.84270	0.842700	2661.16	0.000
2-Way Interactions	1	0.00013	0.000133	0.42	0.535
Shape*Voltage	1	0.00013	0.000133	0.42	0.535
Error	8	0.00253	0.000317		
Total	11	1.08620			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0177951	99.77%	99.68%	99.48%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	2.73000	0.00514	531.44	0.000	
Shape					
Parabolic	-0.14167	0.00514	-27.58	0.000	1.00
Voltage					
17500	-0.26500	0.00514	-51.59	0.000	1.00
Shape*Voltage					
Parabolic 17500	-0.00333	0.00514	-0.65	0.535	1.00

Regression Equation

```
Response = 2.73000 - 0.14167 Shape_Parabolic + 0.14167 Shape_Conical -
 0.26500 Voltage_17500
           + 0.26500 Voltage_20750 - 0.00333 Shape*Voltage_Parabolic 17500
           + 0.00333 Shape*Voltage_Parabolic 20750 + 0.00333 Shape*Voltage_Conical
17500
           - 0.00333 Shape*Voltage_Conical 20750
```

APPENDIX G

The following tables are the secondary Microsoft Excel calculated 2 factor 2 level DOE results.

Anova: Two-Factor With Replication (Material Analysis @ 10mm)						
SUMMARY	Conductive Graphite	Aluminum	Total			
7,500 V						
Count	3	3	6			
Sum	3.081	3.31	6.391			
Average	1.027	1.103333333	1.065166667			
Variance	0.000247	0.000433333	0.002020167			
10,000 V						
Count	3	3	6			
Sum	5.16	5.08	10.24			
Average	1.72	1.693333333	1.706666667			
Variance	0.0003	0.000233333	0.000426667			
Total						
Count	6	6				
Sum	8.241	8.39				
Average	1.3735	1.398333333				
Variance	0.1442935	0.104696667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	1.23456675	1	1.23456675	4068.88245	4.05739E-12	5.31765507
Columns	0.001850083	1	0.001850083	6.097500687	0.038752009	5.31765507
Interaction	0.00795675	1	0.00795675	26.2238396	0.00090616	5.31765507
Within	0.002427333	8	0.000303417			
Total	1.246800917	11				

Anova: Two-Factor With Replication (Shape Analysis @ 10mm)						
SUMMARY	Parabolic	Conical	Total			
11,000 V						
Count	3	3	6			
Sum	5.97	6.24	12.21			
Average	1.99	2.08	2.035			
Variance	0.0004	0.0003	0.00271			
13,000 V						
Count	3	3	6			
Sum	7.62	7.69	15.31			
Average	2.54	2.563333333	2.551666667			
Variance	0.0003	0.000433333	0.000456667			
Total						
Count	6	6				
Sum	13.59	13.93				
Average	2.265	2.321666667				
Variance	0.09103	0.070376667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	0.800833333	1	0.800833333	2234.883721	4.43212E-11	5.31765507
Columns	0.009633333	1	0.009633333	26.88372093	0.000837665	5.31765507
Interaction	0.003333333	1	0.003333333	9.302325581	0.015821724	5.31765507
Within	0.002866667	8	0.000358333			
Total	0.816666667	11				

Anova: Two-Factor With Replication (Material Analysis @ 15mm)

SUMMARY	Conductive Graphite	Aluminum	Total			
10,000 V						
Count	3	3	6			
Sum	3.74	3.53	7.27			
Average	1.246666667	1.176666667	1.211666667			
Variance	0.000433333	0.000233333	0.001736667			
15,000 V						
Count	3	3	6			
Sum	6.79	6.24	13.03			
Average	2.263333333	2.08	2.171666667			
Variance	0.000133333	0.0003	0.010256667			
Total						
Count	6	6				
Sum	10.53	9.77				
Average	1.755	1.628333333				
Variance	0.31031	0.245016667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	2.7648	1	2.7648	10053.82	1.09308E-13	5.317655
Columns	0.048133333	1	0.048133333	175.0303	1.01593E-06	5.317655
Interaction	0.009633333	1	0.009633333	35.0303	0.000354233	5.317655
Within	0.0022	8	0.000275			
Total	2.824766667	11				

Anova: Two-Factor With Replication (Shape Analysis @ 15mm)						
SUMMARY	Parabolic	Conical	Total			
15,000 V						
Count	3	3	6			
Sum	7.44	7.53	14.97			
Average	2.48	2.51	2.495			
Variance	0.0004	0.0003	0.00055			
18,000 V						
Count	3	3	6			
Sum	8.72	9.38	18.1			
Average	2.906666667	3.126666667	3.016666667			
Variance	0.000533333	0.000433333	0.014906667			
Total						
Count	6	6				
Sum	16.16	16.91				
Average	2.693333333	2.818333333				
Variance	0.054986667	0.114376667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	0.816408333	1	0.816408333	1959.38	7.48812E-11	5.317655
Columns	0.046875	1	0.046875	112.5	5.45936E-06	5.317655
Interaction	0.027075	1	0.027075	64.98	4.13423E-05	5.317655
Within	0.003333333	8	0.000416667			
Total	0.893691667	11				

Anova: Two-Factor With Replication (Material Analysis @ 20mm)						
SUMMARY	Conductive Graphite	Aluminum	Total			
10,000 V						
Count	3	3	6			
Sum	2.68	3.144	5.824			
Average	0.893333333	1.048	0.970666667			
Variance	0.000233333	0.000292	0.007386667			
17,500 V						
Count	3	3	6			
Sum	6.22	6.2	12.42			
Average	2.073333333	2.066666667	2.07			
Variance	0.000133333	0.000233333	0.00016			
Total						
Count	6	6				
Sum	8.9	9.344				
Average	1.483333333	1.557333333				
Variance	0.417866667	0.311514667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	3.625601333	1	3.625601333	16258.3	1.6001E-14	5.317655
Columns	0.016428	1	0.016428	73.66816	2.62287E-05	5.317655
Interaction	0.019521333	1	0.019521333	87.53961	1.39179E-05	5.317655
Within	0.001784	8	0.000223			
Total	3.663334667	11				

Anova: Two-Factor With Replication (Material Analysis @ 20mm)						
SUMMARY	Parabolic	Conical	Total			
17,500 V						
Count	3	3	6			
Sum	6.96	7.83	14.79			
Average	2.32	2.61	2.465			
Variance	0.0003	0.0004	0.02551			
20,750 V						
Count	3	3	6			
Sum	8.57	9.4	17.97			
Average	2.856666667	3.133333333	2.995			
Variance	0.000433333	0.000133333	0.02319			
Total						
Count	6	6				
Sum	15.53	17.23				
Average	2.588333333	2.871666667				
Variance	0.086696667	0.082376667				
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	0.8427	1	0.8427	2661.158	2.20924E-11	5.317655
Columns	0.240833333	1	0.240833333	760.5263	3.22403E-09	5.317655
Interaction	0.000133333	1	0.000133333	0.421053	0.534592148	5.317655
Within	0.002533333	8	0.000316667			
Total	1.0862	11				

APPENDIX H

The following Matlab® code was used for determining the maximum efficiency values of the tested ionic air moving devices.

```
% Aaron Griffin
% Thesis Data Analysis
% Calculation of Maximum Efficiency Values

close all
clear all

% Material Analysis

% BEGINNING OF ALUMINUM DATA FOR MATERIAL ANALYSIS

% 10mm distance

% Aluminum / Cylindrical / 7,500 V / 10mm

P1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442 1.49304 1.74188 1.99072
2.23956 ] ;
Eff1 = [ 0 0.000963 0.001673 0.002121 0.002628 0.00288 0.002504 0.002453
0.001709 0 ] ;


p1 = polyfit(P1, Eff1, 3);
y1 = polyval(p1,P1);

Alum_Cylin_7500V = max(y1);

indexmax1 = find(max(y1) == y1);
xmax1 = P1(indexmax1);
ymax1 = y1(indexmax1);


% Aluminum / Cylindrical / 8,750 V / 10mm

P2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442 1.49304 1.74188 1.99072
2.23956 2.4884 2.73724 2.98608 3.23492 ] ;
Eff2 = [ 0 0.000569 0.001043 0.001453 0.001784 0.002104 0.002248 0.002405
0.002521 0.002505 0.002292 0.002038 0.000899 0 ] ;


p2 = polyfit(P2, Eff2, 3);
y2 = polyval(p2,P2);

Alum_Cylin_8750V = max(y2);

indexmax2 = find(max(y2) == y2);
xmax2 = P2(indexmax2);
ymax2 = y2(indexmax2);
```

```
% Aluminum / Cylindrical / 10,000 V / 10mm

P3 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442 1.49304 1.74188 1.99072
2.23956 2.4884 2.73724 2.98608 3.23492 3.48376 3.7326 3.98144 4.23028 4.47912
] ;
Eff3 = [ 0 0.000344 0.000669 0.000959 0.001232 0.001447 0.001668 0.00184
0.001945 0.002039 0.001992 0.002023 0.001981 0.001905 0.001638 0.001405
0.001201 0.00071 0 ] ;

p3 = polyfit(P3, Eff3, 3);
y3 = polyval(p3,P3);

Alum_Cylin_10000V = max(y3);

indexmax3 = find(max(y3) == y3);
xmax3 = P3(indexmax3);
ymax3 = y3(indexmax3);


% 15mm distance

% Aluminum / Cylindrical / 10,000 V / 15mm

P1_1 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 ] ;
Eff1_1 = [ 0 0.001035582 0.001957126 0.002488346 0.003021679 0.003336434
0.003299155 0.002870451 0.00238583 0 ] ;

p1_1 = polyfit(P1_1, Eff1_1, 3);
y1_1 = polyval(p1_1,P1_1);

Alum_Cylin_1000V_1 = max(y1_1);

indexmax1_1 = find(max(y1_1) == y1_1);
xmax1_1 = P1_1(indexmax1_1);
ymax1_1 = y1_1(indexmax1_1);


% Aluminum / Cylindrical / 12,500 V / 15mm

P2_1 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 ] ;
Eff2_1 = [ 0 0.000388247 0.000763762 0.001104091 0.001456138 0.00172281
0.002008129 0.002228824 0.002463112 0.002546926 0.002677843 0.002602432
0.002578521 0.002472527 0.002144196 0.001985324 0.001797973 0.001118794
0.000513601 0 ] ;


p2_1 = polyfit(P2_1, Eff2_1, 3);
y2_1 = polyval(p2_1,P2_1);
```

```
Alum_Cylin_12500V_1 = max(y2_1);

indexmax2_1 = find(max(y2_1) == y2_1);
xmax2_1 = P2_1(indexmax2_1);
ymax2_1 = y2_1(indexmax2_1);


% Aluminum / Cylindrical / 15,000 V / 15mm

P3_1 = [ 0  0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072 2.23956
2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 4.47912
4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221 ] ;
Eff3_1 = [ 0 0.000124168 0.000182376 0.000236618 0.000274764 0.000380076
0.000446087 0.000533322 0.000604525 0.000678259 0.0007185 0.000767826
0.001175354 0.00122512  0.001226357 0.00112413  0.001112899 0.00111155
0.001004357 0.000990305 0.000649327 0.000597702 0.000396772 0.000205569 0 ] ;

p3_1 = polyfit(P3_1, Eff3_1, 3);
y3_1 = polyval(p3_1,P3_1);

Alum_Cylin_15000V_1 = max(y3_1);

indexmax3_1 = find(max(y3_1) == y3_1);
xmax3_1 = P3_1(indexmax3_1);
ymax3_1 = y3_1(indexmax3_1);


% 20mm distance

% Aluminum / Cylindrical / 10,000 V / 20mm

P1_2 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 ];
Eff1_2 = [ 0 0.027228313 0.047416803 0.059407229 0.070408568 0.062982665
0.036135167 0 ];

p1_2 = polyfit(P1_2, Eff1_2, 3);
y1_2 = polyval(p1_2,P1_2);

Alum_Cylin_1000V_2 = max(y1_2);

indexmax1_2 = find(max(y1_2) == y1_2);
xmax1_2 = P1_2(indexmax1_2);
ymax1_2 = y1_2(indexmax1_2);


% Aluminum / Cylindrical / 15,000 V / 20mm

P2_2 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 ];
Eff2_2 = [ 0 0.000391412 0.000782824    0.001192082 0.001563704 0.001858592
0.002102028 0.002336295 0.002529124 0.002670079 0.002661102 0.002527943
0.002537257 0.002366907 0.001710361 0.001324868 0.000500241 0 ];
```

```
p2_2 = polyfit(P2_2, Eff2_2, 3);
y2_2 = polyval(p2_2,P2_2);

Alum_Cylin_15000V_2 = max(y2_2);

indexmax2_2 = find(max(y2_2) == y2_2);
xmax2_2 = P2_2(indexmax2_2);
ymax2_2 = y2_2(indexmax2_2);


% Aluminum / Cylindrical / 17,500 V / 20mm

P3_2 = [ 0  0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072 2.23956
2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 4.47912
4.72796 4.9768  5.22564 5.47448 5.72332 ];
Eff3_2 = [ 0    0.000226348 0.000339401 0.00045298  0.000571662 0.000681117
0.00077935  0.000863676 0.000952006 0.001036522 0.00109222  0.001081626
0.001094784 0.001056954 0.001025438 0.001023083 0.000947111 0.000936447
0.000900959 0.000620751 0.000485139 0.00016082  0 ];

p3_2 = polyfit(P3_2, Eff3_2, 3);
y3_2 = polyval(p3_2,P3_2);

Alum_Cylin_17500V_2 = max(y3_2);

indexmax3_2 = find(max(y3_2) == y3_2);
xmax3_2 = P3_2(indexmax3_2);
ymax3_2 = y3_2(indexmax3_2);


% FIGURE OF ALUMINUM EFFICENCY CURVES AT 10, 15, AND 20 MM.

figure(1);

% 10mm distance

subplot(3,3,1);
hold on
plot(P1, Eff1,'o')
plot(P1,y1)
grid on
strmax1 = ['Max Eff = ',num2str(ymax1)];
text(xmax1,ymax1,strmax1,'HorizontalAlignment','right');
title('Aluminum / 7,500V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0035]);
hold off

subplot(3,3,4);
hold on
plot(P2, Eff2,'o')
plot(P2,y2)
grid on
```

```
strmax2 = ['Max Eff = ',num2str(ymax2)];
text(xmax2,ymax2,strmax2,'HorizontalAlignment','right');
title('Aluminum / 8,750V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,7);
hold on
plot(P3, Eff3,'o')
plot(P3,y3)
grid on
strmax3 = ['Max Eff = ',num2str(ymax3)];
text(xmax3,ymax3,strmax3,'HorizontalAlignment','right');
title('Aluminum / 10,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

% 15mm distance

subplot(3,3,2);
hold on
plot(P1_1, Eff1_1,'o')
plot(P1_1,y1_1)
grid on
strmax1_1 = ['Max Eff = ',num2str(ymax1_1)];
text(xmax1_1,ymax1_1,strmax1_1,'HorizontalAlignment','right');
title('Aluminum / 10,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,5);
hold on
plot(P2_1, Eff2_1,'o')
plot(P2_1,y2_1)
grid on
strmax2_1 = ['Max Eff = ',num2str(ymax2_1)];
text(xmax2_1,ymax2_1,strmax2_1,'HorizontalAlignment','right');
title('Aluminum / 12,500V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.003]);
hold off

subplot(3,3,8);
hold on
plot(P3_1, Eff3_1,'o')
plot(P3_1,y3_1)
grid on
strmax3_1 = ['Max Eff = ',num2str(ymax3_1)];
text(xmax3_1,ymax3_1,strmax3_1,'HorizontalAlignment','right');
title('Aluminum / 15,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
```

```
xlim([0,6.5]);
ylim([0,0.0014]);
hold off


% 20mm distance

subplot(3,3,3);
hold on
plot(P1_2, Eff1_2,'o')
plot(P1_2,y1_2)
grid on
strmax1_2 = ['Max Eff = ',num2str(ymax1_2)];
text(xmax1_2,ymax1_2,strmax1_2,'HorizontalAlignment','right');
title('Aluminum / 10,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.08]);
hold off

subplot(3,3,6);
hold on
plot(P2_2, Eff2_2,'o')
plot(P2_2,y2_2)
grid on
strmax2_2 = ['Max Eff = ',num2str(ymax2_2)];
text(xmax2_2,ymax2_2,strmax2_2,'HorizontalAlignment','right');
title('Aluminum / 15,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.003]);
hold off

subplot(3,3,9);
hold on
plot(P3_2, Eff3_2,'o')
plot(P3_2,y3_2)
grid on
strmax3_2 = ['Max Eff = ',num2str(ymax3_2)];
text(xmax3_2,ymax3_2,strmax3_2,'HorizontalAlignment','right');
title('Aluminum / 17,500V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0013]);
hold off


% BEGINNING OF CONDUCTIVE GRAPHITE DATA FOR MATERIAL ANALYSIS

% 10mm distance

% Conductive Graphite / Cylindrical / 7,500 V / 10mm

P4 = [ 0    0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884 ];
```

```
Eff4 = [ 0  0.00088192  0.001611113 0.002269422 0.002591764 0.002913223
0.00274025  0.002600805 0.001978765 0.00153106  0 ];

p4 = polyfit(P4, Eff4, 2);
y4 = polyval(p4,P4);

CondGrap_Cylin_7500V = max(y4);

indexmax4 = find(max(y4) == y4);
xmax4 = P4(indexmax4);
ymax4 = y4(indexmax4);


% Conductive Graphite / Cylindrical / 8,750 V / 10mm

P5 = [ 0    0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326 ];
Eff5 = [ 0  0.000547099 0.001052835 0.001494865 0.001836645 0.002223819
0.002439579 0.002522    0.002724391 0.002684327 0.00257181  0.002305458
0.00211541  0.001449696 0.000824135 0 ];

p5 = polyfit(P5, Eff5, 3);
y5 = polyval(p5,P5);

CondGrap_Cylin_8750V = max(y5);

indexmax5 = find(max(y5) == y5);
xmax5 = P5(indexmax5);
ymax5 = y5(indexmax5);


% Conductive Graphite / Cylindrical / 10,000 V / 10mm

P6 = [ 0    0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 ];
Eff6 = [ 0  0.000359824 0.000701965 0.00102045  0.001308602 0.001590551
0.001791004 0.002016987 0.002169456 0.002266296 0.002423004 0.002368359
0.002383712 0.002278673 0.00226147  0.001993635 0.00194502  0.00181161
0.00164415  0.001200539 0.001087401 0 ];

p6 = polyfit(P6, Eff6, 3);
y6 = polyval(p6,P6);

CondGrap_Cylin_10000V = max(y6);

indexmax6 = find(max(y6) == y6);
xmax6 = P6(indexmax6);
ymax6 = y6(indexmax6);


% 15mm distance
```

```
% Conductive Graphite / Cylindrical / 10,000 V / 15mm

P4_1 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 ];
Eff4_1 = [ 0    0.000990644 0.001872681 0.002672756 0.003327447 0.003777767
0.003892743 0.003992936 0.003731404 0.003051768 0.002348786 0.001337969 0 ];

p4_1 = polyfit(P4_1, Eff4_1, 2);
y4_1 = polyval(p4_1,P4_1);

CondGrap_Cylin_10000V_1 = max(y4_1);

indexmax4_1 = find(max(y4_1) == y4_1);
xmax4_1 = P4_1(indexmax4_1);
ymax4_1 = y4_1(indexmax4_1);


% Conductive Graphite / Cylindrical / 12,500 V / 15mm

P5_1 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768 ];
Eff5_1 = [ 0    0.000441826 0.000874809 0.001274136 0.001641569 0.001972461
0.002267258 0.002539298 0.002776787 0.00295947  0.003096723 0.003042983
0.003029348 0.003087348 0.002886397 0.002826394 0.002401652 0.002046519
0.001606097 0.0007978   0 ];

p5_1 = polyfit(P5_1, Eff5_1, 3);
y5_1 = polyval(p5_1,P5_1);

CondGrap_Cylin_12500V_1 = max(y5_1);

indexmax5_1 = find(max(y5_1) == y5_1);
xmax5_1 = P5_1(indexmax5_1);
ymax5_1 = y5_1(indexmax5_1);


% Conductive Graphite / Cylindrical / 15,000 V / 15mm

P6_1 = [ 0  0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072 2.23956
2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 4.47912
4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984 6.71868
6.96752 7.21636 7.4652 ];
Eff6_1 = [ 0    0.000450592 0.00067555  0.000887598 0.001106312 0.001275962
0.001449633 0.00163839  0.001807003 0.001925409 0.002093904 0.002192625
0.002342351 0.002347718 0.002415985 0.002501944 0.00250129  0.002445843
0.002489561 0.002322156 0.002198182 0.002191343 0.00207208  0.00183509
0.001689195 0.001529492 0.001384278 0.000927124 0.000373232 0 ];

p6_1 = polyfit(P6_1, Eff6_1, 3);
y6_1 = polyval(p6_1,P6_1);

CondGrap_Cylin_15000V_1 = max(y6_1);
```

```
indexmax6_1 = find(max(y6_1) == y6_1);
xmax6_1 = P6_1(indexmax6_1);
ymax6_1 = y6_1(indexmax6_1);



% 20mm distance

% Conductive Graphite / Cylindrical / 10,000 V / 20mm

P4_2 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 ];
Eff4_2 = [ 0    0.005759761 0.011661804 0.015413907 0.014870011 0.01036229
0.0060664   0 ];

p4_2 = polyfit(P4_2, Eff4_2, 2);
y4_2 = polyval(p4_2,P4_2);

CondGrap_Cylin_10000V_2 = max(y4_2);

indexmax4_2 = find(max(y4_2) == y4_2);
xmax4_2 = P4_2(indexmax4_2);
ymax4_2 = y4_2(indexmax4_2);


% Conductive Graphite / Cylindrical / 15,000 V / 20mm

P5_2 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 ];
Eff5_2 = [ 0    0.000519865 0.001041748 0.001523799 0.001944273 0.002316164
0.002712405 0.002940183 0.00318571  0.003353943 0.003408439 0.003182775
0.003187638 0.002742038 0.002576088 0.001634409 0.000923639 0 ];

p5_2 = polyfit(P5_2, Eff5_2, 3);
y5_2 = polyval(p5_2,P5_2);

CondGrap_Cylin_15000V_2 = max(y5_2);

indexmax5_2 = find(max(y5_2) == y5_2);
xmax5_2 = P5_2(indexmax5_2);
ymax5_2 = y5_2(indexmax5_2);


% Conductive Graphite / Cylindrical / 17,500 V / 20mm

P6_2 = [ 0  0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072 2.23956
2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 4.47912
4.72796 4.9768  5.22564 5.47448 5.72332 ];
Eff6_2 = [ 0    0.000559699 0.000829726 0.001046057 0.001268677 0.001489136
0.001685314 0.00189416  0.002013245 0.002109892 0.002204002 0.002263363
0.00230287  0.002324964 0.00231683  0.002096128 0.001989038 0.001777825
0.001564957 0.001443761 0.001239237 0.000691583 0 ];

p6_2 = polyfit(P6_2, Eff6_2, 3);
```

```
y6_2 = polyval(p6_2,P6_2);

CondGrap_Cylin_17500V_2 = max(y6_2);

indexmax6_2 = find(max(y6_2) == y6_2);
xmax6_2 = P6_2(indexmax6_2);
ymax6_2 = y6_2(indexmax6_2);


% FIGURE OF CONDUCTIVE GRAPHITE EFFICENCY CURVES AT 10, 15, AND 20 MM.

figure(2);

% 10mm distance

subplot(3,3,1);
hold on
plot(P4, Eff4,'o')
plot(P4,y4)
grid on
strmax4 = ['Max Eff = ',num2str(ymax4)];
text(xmax4,ymax4,strmax4,'HorizontalAlignment','right');
title('Conductive Graphite / 7,500V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0035]);
hold off

subplot(3,3,4);
hold on
plot(P5, Eff5,'o')
plot(P5,y5)
grid on
strmax5 = ['Max Eff = ',num2str(ymax5)];
text(xmax5,ymax5,strmax5,'HorizontalAlignment','right');
title('Conductive Graphite / 8,750V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,7);
hold on
plot(P6, Eff6,'o')
plot(P6,y6)
grid on
strmax6 = ['Max Eff = ',num2str(ymax6)];
text(xmax6,ymax6,strmax6,'HorizontalAlignment','right');
title('Conductive Graphite / 10,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

% 15mm distance

subplot(3,3,2);
```

```
hold on
plot(P4_1, Eff4_1,'o')
plot(P4_1,y4_1)
grid on
strmax4_1 = ['Max Eff = ',num2str(ymax4_1)];
text(xmax4_1,ymax4_1,strmax4_1,'HorizontalAlignment','right');
title('Conductive Graphite / 10,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0045]);
hold off

subplot(3,3,5);
hold on
plot(P5_1, Eff5_1,'o')
plot(P5_1,y5_1)
grid on
strmax5_1 = ['Max Eff = ',num2str(ymax5_1)];
text(xmax5_1,ymax5_1,strmax5_1,'HorizontalAlignment','right');
title('Conductive Graphite / 12,500V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,8);
hold on
plot(P6_1, Eff6_1,'o')
plot(P6_1,y6_1)
grid on
strmax6_1 = ['Max Eff = ',num2str(ymax6_1)];
text(xmax6_1,ymax6_1,strmax6_1,'HorizontalAlignment','right');
title('Conductive Graphite / 15,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off


% 20mm distance

subplot(3,3,3);
hold on
plot(P4_2, Eff4_2,'o')
plot(P4_2,y4_2)
grid on
strmax4_2 = ['Max Eff = ',num2str(ymax4_2)];
text(xmax4_2,ymax4_2,strmax4_2,'HorizontalAlignment','right');
title('Conductive Graphite / 10,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.02]);
hold off

subplot(3,3,6);
hold on
plot(P5_2, Eff5_2,'o')
plot(P5_2,y5_2)
```

```
grid on
strmax5_2 = ['Max Eff = ',num2str(ymax5_2)];
text(xmax5_2,ymax5_2,strmax5_2,'HorizontalAlignment','right');
title('Conductive Graphite / 15,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.004]);
hold off

subplot(3,3,9);
hold on
plot(P6_2, Eff6_2,'o')
plot(P6_2,y6_2)
grid on
strmax6_2 = ['Max Eff = ',num2str(ymax6_2)];
text(xmax6_2,ymax6_2,strmax6_2,'HorizontalAlignment','right');
title('Conductive Graphite / 17,500V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off



% BEGINNING OF COPPER DATA FOR MATERIAL ANALYSIS

% 10mm distance

% Copper / Cylindrical / 7,500 V / 10mm

P7 = [ 0    0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
];
Eff7 = [ 0  0.001560768 0.002726193 0.003649098 0.003871435 0.003566486
0.003023964 0.001577996 0 ];

p7 = polyfit(P7, Eff7, 2);
y7 = polyval(p7,P7);

Copper_Cylin_7500V = max(y7);

indexmax7 = find(max(y7) == y7);
xmax7 = P7(indexmax7);
ymax7 = y7(indexmax7);


% Copper / Cylindrical / 8,750 V / 10mm

P8 = [ 0    0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 ];
Eff8 = [ 0  0.000852902 0.001586794 0.002272376 0.00280452  0.003205166
0.003285295 0.003318682 0.003328565 0.002899073 0.00249548  0.001573806 0 ];

p8 = polyfit(P8, Eff8, 2);
y8 = polyval(p8,P8);
```

```
Copper_Cylin_8750V = max(y8);

indexmax8 = find(max(y8) == y8);
xmax8 = P8(indexmax8);
ymax8 = y8(indexmax8);


% Copper / Cylindrical / 10,000 V / 10mm

P9 = [ 0    0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 ];
Eff9 = [ 0  0.000521588 0.001001015 0.001426986 0.001815868 0.002187595
0.002447474 0.002609395 0.002789594 0.002909591 0.002738051 0.002685269
0.002375177 0.002021279 0.001806249 0.001455444 0.000588869 0 ];

p9 = polyfit(P9, Eff9, 2);
y9 = polyval(p9,P9);

Copper_Cylin_10000V = max(y9);

indexmax9 = find(max(y9) == y9);
xmax9 = P9(indexmax9);
ymax9 = y9(indexmax9);



% 15mm distance

% Copper / Cylindrical / 10,000 V / 15mm

P7_1 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 ];
Eff7_1 = [ 0    0.002557146 0.004668394 0.006412638 0.00764487  0.007918624
0.008113077 0.005962302 0.002483298 0 ];

p7_1 = polyfit(P7_1, Eff7_1, 2);
y7_1 = polyval(p7_1,P7_1);

Copper_Cylin_10000V_1 = max(y7_1);

indexmax7_1 = find(max(y7_1) == y7_1);
xmax7_1 = P7_1(indexmax7_1);
ymax7_1 = y7_1(indexmax7_1);


% Copper / Cylindrical / 12,500 V / 15mm

P8_1 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 ];
Eff8_1 = [ 0    0.000454424 0.000870229 0.00124989  0.001621781 0.001918528
0.002199838 0.002329213 0.002603473 0.002651765 0.002514582 0.002422665
0.002228229 0.00194392  0.001756362 0.001288714 0.000753829 0 ];
```

```
p8_1 = polyfit(P8_1, Eff8_1, 2);
y8_1 = polyval(p8_1,P8_1);

Copper_Cylin_12500V_1 = max(y8_1);

indexmax8_1 = find(max(y8_1) == y8_1);
xmax8_1 = P8_1(indexmax8_1);
ymax8_1 = y8_1(indexmax8_1);


% Copper / Cylindrical / 15,000 V / 15mm

P9_1 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221 ];
Eff9_1 = [ 0    9.07276E-05 0.000175929 0.000258505 0.000326067 0.000418045
0.00050267  0.000562013 0.000638544 0.00070006  0.0007181   0.000771744
0.00078798  0.000816839 0.00082382  0.000852744 0.000845762 0.000822324
0.000811669 0.000673614 0.000624361 0.000572331 0.000433319 0.00029446
0.000178389 0 ];

p9_1 = polyfit(P9_1, Eff9_1, 3);
y9_1 = polyval(p9_1,P9_1);

Copper_Cylin_15000V_1 = max(y9_1);

indexmax9_1 = find(max(y9_1) == y9_1);
xmax9_1 = P9_1(indexmax9_1);
ymax9_1 = y9_1(indexmax9_1);



% 20mm distance

% Copper / Cylindrical / 10,000 V / 20mm

P7_2 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 ];
Eff7_2 = [ 0    0.019385912 0.032668964 0.037086092 0.032668964 0.01689774  0
];

p7_2 = polyfit(P7_2, Eff7_2, 2);
y7_2 = polyval(p7_2,P7_2);

Copper_Cylin_10000V_2 = max(y7_2);

indexmax7_2 = find(max(y7_2) == y7_2);
xmax7_2 = P7_2(indexmax7_2);
ymax7_2 = y7_2(indexmax7_2);


% Copper / Cylindrical / 15,000 V / 20mm
```

```
P8_2 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326 ];
Eff8_2 = [ 0    0.000432983 0.000830379 0.001174393 0.001484665 0.001731757
0.001941432 0.002123441 0.002180601 0.002177965 0.002048523 0.001858751
0.00157143  0.00079686  0.000361352 0 ];

p8_2 = polyfit(P8_2, Eff8_2, 3);
y8_2 = polyval(p8_2,P8_2);

Copper_Cylin_15000V_2 = max(y8_2);

indexmax8_2 = find(max(y8_2) == y8_2);
xmax8_2 = P8_2(indexmax8_2);
ymax8_2 = y8_2(indexmax8_2);


% Copper / Cylindrical / 17,500 V / 20mm

P9_2 = [ 0  0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 ];
Eff9_2 = [ 0    0.000113711 0.000219966 0.000318764 0.000405089 0.000481959
0.000555003 0.000617879 0.000705878 0.000764664 0.000835687 0.000870507
0.000888086 0.000872406 0.00087862  0.0008561   0.00081524  0.000771123
0.000603973 0.000369409 0.000136702 0 ];
p9_2 = polyfit(P9_2, Eff9_2, 3);
y9_2 = polyval(p9_2,P9_2);

Copper_Cylin_17500V_2 = max(y9_2);

indexmax9_2 = find(max(y9_2) == y9_2);
xmax9_2 = P9_2(indexmax9_2);
ymax9_2 = y9_2(indexmax9_2);


% FIGURE OF COPPER EFFICENCY CURVES AT 10, 15, AND 20 MM.

figure(3);

% 10mm distance

subplot(3,3,1);
hold on
plot(P7, Eff7,'o')
plot(P7,y7)
grid on
strmax7 = ['Max Eff = ',num2str(ymax7)];
text(xmax7,ymax7,strmax7,'HorizontalAlignment','right');
title('Copper / 7,500V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0045]);
hold off
```

```
subplot(3,3,4);
hold on
plot(P8, Eff8,'o')
plot(P8,y8)
grid on
strmax8 = ['Max Eff = ',num2str(ymax8)];
text(xmax8,ymax8,strmax8,'HorizontalAlignment','right');
title('Copper / 8,750V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.004]);
hold off

subplot(3,3,7);
hold on
plot(P9, Eff9,'o')
plot(P9,y9)
grid on
strmax9 = ['Max Eff = ',num2str(ymax9)];
text(xmax9,ymax9,strmax9,'HorizontalAlignment','right');
title('Copper / 10,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0035]);
hold off

% 15mm distance

subplot(3,3,2);
hold on
plot(P7_1, Eff7_1,'o')
plot(P7_1,y7_1)
grid on
strmax7_1 = ['Max Eff = ',num2str(ymax7_1)];
text(xmax7_1,ymax7_1,strmax7_1,'HorizontalAlignment','right');
title('Copper / 10,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.01]);
hold off

subplot(3,3,5);
hold on
plot(P8_1, Eff8_1,'o')
plot(P8_1,y8_1)
grid on
strmax8_1 = ['Max Eff = ',num2str(ymax8_1)];
text(xmax8_1,ymax8_1,strmax8_1,'HorizontalAlignment','right');
title('Copper / 12,500V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.003]);
hold off

subplot(3,3,8);
hold on
```

```
plot(P9_1, Eff9_1,'o')
plot(P9_1,y9_1)
grid on
strmax9_1 = ['Max Eff = ',num2str(ymax9_1)];
text(xmax9_1,ymax9_1,strmax9_1,'HorizontalAlignment','right');
title('Copper / 15,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off


% 20mm distance

subplot(3,3,3);
hold on
plot(P7_2, Eff7_2,'o')
plot(P7_2,y7_2)
grid on
strmax7_2 = ['Max Eff = ',num2str(ymax7_2)];
text(xmax7_2,ymax7_2,strmax7_2,'HorizontalAlignment','right');
title('Copper / 10,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.045]);
hold off

subplot(3,3,6);
hold on
plot(P8_2, Eff8_2,'o')
plot(P8_2,y8_2)
grid on
strmax8_2 = ['Max Eff = ',num2str(ymax8_2)];
text(xmax8_2,ymax8_2,strmax8_2,'HorizontalAlignment','right');
title('Copper / 15,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.003]);
hold off

subplot(3,3,9);
hold on
plot(P9_2, Eff9_2,'o')
plot(P9_2,y9_2)
grid on
strmax9_2 = ['Max Eff = ',num2str(ymax9_2)];
text(xmax9_2,ymax9_2,strmax9_2,'HorizontalAlignment','right');
title('Copper / 17,500V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.001]);
hold off



% BEGINNING OF CYLINDRICAL DATA FOR SHAPE ANALYSIS
```

```
% 10mm distance

% Cylindrical / 11,000 V / 10mm

P10 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 ];
Eff10 = [ 0 0.000294058 0.000582344 0.00084101  0.001092929 0.001334537
0.001525186 0.001757033 0.001884452 0.002041458 0.002114794 0.002194952
0.002213837 0.002198464 0.002243242 0.002183788 0.002159485 0.002003345
0.001896448 0.001704338 0.001618154 0.000926456 0.000427759 0 ];

p10 = polyfit(P10, Eff10, 3);
y10 = polyval(p10,P10);

Cylin_11000V = max(y10);

indexmax10 = find(max(y10) == y10);
xmax10 = P10(indexmax10);
ymax10 = y10(indexmax10);


% Cylindrical / 12,000 V / 10mm

P11 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 ];
Eff11 = [ 0 0.000242544 0.000477883 0.000698814 0.000911091 0.001110195
0.001312021 0.001498839 0.00163959  0.001807601 0.001945164 0.002048615
0.002117997 0.002220901 0.002306492 0.002223115 0.002295806 0.002257313
0.002237994 0.002177952 0.002166595 0.001998811 0.00190845  0.001725056
0.001723611 0.001439207 0.001034102 0.00058503  0 ];

p11 = polyfit(P11, Eff11, 2);
y11 = polyval(p11,P11);

Cylin_12000V = max(y11);

indexmax11 = find(max(y11) == y11);
xmax11 = P11(indexmax11);
ymax11 = y11(indexmax11);


% Cylindrical / 13,000 V / 10mm

P12 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 ];
Eff12 = [ 0 0.000183074 0.000356555 0.000530036 0.000693923 0.00084342
0.000992918 0.001151808 0.001303447 0.001430081 0.001556716 0.00168577
0.001780947 0.001866446 0.001976142 0.001984208 0.002090677 0.002084225
```

```
0.002072176 0.00206578  0.002094561 0.002083418 0.002040198 0.002004223
0.001976242 0.001955977 0.001813098 0.001775853 0.001739005 0.001553332
0.001415028 0.001288714 0.00101432  0.000732213 0 ];

p12 = polyfit(P12, Eff12, 3);
y12 = polyval(p12,P12);

Cylin_13000V = max(y12);

indexmax12 = find(max(y12) == y12);
xmax12 = P12(indexmax12);
ymax12 = y12(indexmax12);



% 15mm distance

% Cylindrical / 15,000 V / 15mm

P10_1 = [ 0 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072 2.23956
2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 4.47912
4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984 6.71868
6.96752 7.21636 7.4652 ];
Eff10_1 = [ 0   0.000450592 0.00067555  0.000887598 0.001106312 0.001275962
0.001449633 0.00163839  0.001807003 0.001925409 0.002093904 0.002192625
0.002342351 0.002347718 0.002415985 0.002501944 0.00250129  0.002445843
0.002489561 0.002322156 0.002198182 0.002191343 0.00207208  0.00183509
0.001689195 0.001529492 0.001384278 0.000927124 0.000373232 0 ];

p10_1 = polyfit(P10_1, Eff10_1, 3);
y10_1 = polyval(p10_1,P10_1);

Cylin_15000V_1 = max(y10_1);

indexmax10_1 = find(max(y10_1) == y10_1);
xmax10_1 = P10_1(indexmax10_1);
ymax10_1 = y10_1(indexmax10_1);


% Cylindrical / 16,750 V / 15mm

P11_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094 ];
Eff11_1 = [ 0   0.000148836 0.000304673 0.00046196  0.00061382  0.000750738
0.00088898  0.001037673 0.001132195 0.001286073 0.001429227 0.001542486
0.001610596 0.001733579 0.001838061 0.001907486 0.00194955  0.002056648
0.002140509 0.002215849 0.002213371 0.002186693 0.002168644 0.002075623
0.001993115 0.001974056 0.001967329 0.001856293 0.001789944 0.001684715
0.001428718 0.001187377 0.001196595 0.001047726 0.000652183 0 ];

p11_1 = polyfit(P11_1, Eff11_1, 3);
y11_1 = polyval(p11_1,P11_1);
```

```
Cylin_16750V_1 = max(y11_1);

indexmax11_1 = find(max(y11_1) == y11_1);
xmax11_1 = P11_1(indexmax11_1);
ymax11_1 = y11_1(indexmax11_1);


% Cylindrical / 18,000 V / 15mm

P12_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 9.70476 9.9536  10.20244 ];
Eff12_1 = [ 0   5.02923E-05 0.000100742 0.00015038  0.000197734 0.000272595
0.00037593  0.000456708 0.000500821 0.000579795 0.000617821 0.000702217
0.000772396 0.000814246 0.000876386 0.000896384 0.000972077 0.000980981
0.00107109  0.001103163 0.001137282 0.001201294 0.001193905 0.001180028
0.00121627  0.001160874 0.001174991 0.001158305 0.001163314 0.001061209
0.000978661 0.001006444 0.000974311 0.000929957 0.000864933 0.000785963
0.000678778 0.000565448 0.000500404 0.000374862 0.000237251 0 ];

p12_1 = polyfit(P12_1, Eff12_1, 3);
y12_1 = polyval(p12_1,P12_1);

Cylin_18000V_1 = max(y12_1);

indexmax12_1 = find(max(y12_1) == y12_1);
xmax12_1 = P12_1(indexmax12_1);
ymax12_1 = y12_1(indexmax12_1);



% 20mm distance

% Cylindrical / 17,500 V / 20mm

P10_2 = [ 0 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072 2.23956
2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 4.47912
4.72796 4.9768  5.22564 5.47448 5.72332 ];
Eff10_2 = [ 0   0.000559699 0.000829726 0.001046057 0.001268677 0.001489136
0.001685314 0.00189416  0.002013245 0.002109892 0.002204002 0.002263363
0.00230287  0.002324964 0.00231683  0.002096128 0.001989038 0.001777825
0.001564957 0.001443761 0.001239237 0.000691583 0 ];

p10_2 = polyfit(P10_2, Eff10_2, 3);
y10_2 = polyval(p10_2,P10_2);

Cylin_17500V_2 = max(y10_2);

indexmax10_2 = find(max(y10_2) == y10_2);
xmax10_2 = P10_2(indexmax10_2);
ymax10_2 = y10_2(indexmax10_2);
```

```
% Cylindrical / 19,500 V / 20mm

P11_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 ];
Eff11_2 = [ 0   0.000162971 0.00032429  0.000476262 0.00062949  0.000763154
0.000904463 0.001038054 0.001162136 0.001278173 0.001381456 0.001473109
0.001538248 0.001633163 0.001633938 0.001665885 0.001699081 0.001748309
0.001692183 0.001666428 0.001601199 0.001505998 0.001427616 0.001245667
0.001085347 0.000820605 0.000483732 0 ];

p11_2 = polyfit(P11_2, Eff11_2, 3);
y11_2 = polyval(p11_2,P11_2);

Cylin_19500V_2 = max(y11_2);

indexmax11_2 = find(max(y11_2) == y11_2);
xmax11_2 = P11_2(indexmax11_2);
ymax11_2 = y11_2(indexmax11_2);


% Cylindrical / 20,750 V / 20mm

P12_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 ];
Eff12_2 = [ 0   9.22568E-05 0.000181574 0.000271891 0.000364811 0.000449906
0.000532533 0.000606915 0.000683984 0.000760424 0.000818421 0.000882347
0.000954771 0.000998537 0.001060282 0.001071735 0.001106072 0.001132748
0.001162236 0.001214601 0.001155692 0.001155527 0.001141378 0.001057661
0.001023402 0.000901292 0.000890925 0.000784996 0.00058613  0.0004436
0.000367117 0.000164854 0 ];

p12_2 = polyfit(P12_2, Eff12_2, 3);
y12_2 = polyval(p12_2,P12_2);

Cylin_20750V_2 = max(y12_2);

indexmax12_2 = find(max(y12_2) == y12_2);
xmax12_2 = P12_2(indexmax12_2);
ymax12_2 = y12_2(indexmax12_2);


% FIGURE OF CYLINDRICAL EFFICIENCY CURVES AT 10, 15, AND 20 MM.

figure(4);

% 10mm distance
```

```
subplot(3,3,1);
hold on
plot(P10, Eff10,'o')
plot(P10,y10)
grid on
strmax10 = ['Max Eff = ',num2str(ymax10)];
text(xmax10,ymax10,strmax10,'HorizontalAlignment','right');
title('Cylindrical / 11,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.003]);
hold off

subplot(3,3,4);
hold on
plot(P11, Eff11,'o')
plot(P11,y11)
grid on
strmax11 = ['Max Eff = ',num2str(ymax11)];
text(xmax11,ymax11,strmax11,'HorizontalAlignment','right');
title('Cylindrical / 12,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.003]);
hold off

subplot(3,3,7);
hold on
plot(P12, Eff12,'o')
plot(P12,y12)
grid on
strmax12 = ['Max Eff = ',num2str(ymax12)];
text(xmax12,ymax12,strmax12,'HorizontalAlignment','right');
title('Cylindrical / 13,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0025]);
hold off

% 15mm distance

subplot(3,3,2);
hold on
plot(P10_1, Eff10_1,'o')
plot(P10_1,y10_1)
grid on
strmax10_1 = ['Max Eff = ',num2str(ymax10_1)];
text(xmax10_1,ymax10_1,strmax10_1,'HorizontalAlignment','right');
title('Cylindrical / 15,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.003]);
hold off

subplot(3,3,5);
hold on
```

```
plot(P11_1, Eff11_1,'o')
plot(P11_1,y11_1)
grid on
strmax11_1 = ['Max Eff = ',num2str(ymax11_1)];
text(xmax11_1,ymax11_1,strmax11_1,'HorizontalAlignment','right');
title('Cylindrical / 16,750V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0025]);
hold off

subplot(3,3,8);
hold on
plot(P12_1, Eff12_1,'o')
plot(P12_1,y12_1)
grid on
strmax12_1 = ['Max Eff = ',num2str(ymax12_1)];
text(xmax12_1,ymax12_1,strmax12_1,'HorizontalAlignment','right');
title('Cylindrical / 18,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off


% 20mm distance

subplot(3,3,3);
hold on
plot(P10_2, Eff10_2,'o')
plot(P10_2,y10_2)
grid on
strmax10_2 = ['Max Eff = ',num2str(ymax10_2)];
text(xmax10_2,ymax10_2,strmax10_2,'HorizontalAlignment','right');
title('Cylindrical / 17,500V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.003]);
hold off

subplot(3,3,6);
hold on
plot(P11_2, Eff11_2,'o')
plot(P11_2,y11_2)
grid on
strmax11_2 = ['Max Eff = ',num2str(ymax11_2)];
text(xmax11_2,ymax11_2,strmax11_2,'HorizontalAlignment','right');
title('Cylindrical / 19,500V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.002]);
hold off

subplot(3,3,9);
hold on
plot(P12_2, Eff12_2,'o')
```

```
plot(P12_2,y12_2)
grid on
strmax12_2 = ['Max Eff = ',num2str(ymax12_2)];
text(xmax12_2,ymax12_2,strmax12_2,'HorizontalAlignment','right');
title('Cylindrical / 20,750V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off



% BEGINNING OF CONICAL DATA FOR SHAPE ANALYSIS

% 10mm distance

% Conical / 11,000 V / 10mm

P13 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984 ];
Eff13 = [ 0 0.000103683 0.000204242 0.000301721 0.000390272 0.000474787
0.000560506 0.000642641 0.000702172 0.000775192 0.000814906 0.000863856
0.000905432 0.000942988 0.000991664 0.000993204 0.001018355 0.001012195
0.000965464 0.000960867 0.000935447 0.00091381  0.000694711 0.000477145
0.000390448 0.000206759 0 ];

p13 = polyfit(P13, Eff13, 3);
y13 = polyval(p13,P13);

Cone_11000V = max(y13);

indexmax13 = find(max(y13) == y13);
xmax13 = P13(indexmax13);
ymax13 = y13(indexmax13);


% Conical / 12,000 V / 10mm

P14 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 ];
Eff14 = [ 0 8.26094E-05 0.000161627 0.000236631 0.000307579 0.000374301
0.000444779 0.000505458 0.000568065 0.000625828 0.000673289 0.000706973
0.000759644 0.000793401 0.000834209 0.000866711 0.000901379 0.000914741
0.000942548 0.000936564 0.000949877 0.000947965 0.000948938 0.000921963
0.000896018 0.000788664 0.000739033 0.000526527 0.000455023 0.000378415
0.000247354 0.000163697 0 ];

p14 = polyfit(P14, Eff14, 3);
y14 = polyval(p14,P14);

Cone_12000V = max(y14);
```

```
indexmax14 = find(max(y14) == y14);
xmax14 = P14(indexmax14);
ymax14 = y14(indexmax14);


% Conical / 13,000 V / 10mm

P15 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 ];
Eff15 = [ 0 6.65648E-05 0.000130108 0.000192001 0.00024817  0.000305516
0.000358741 0.000411858 0.0004637   0.000520442 0.000558737 0.000604366
0.000668118 0.000691433 0.000722703 0.000756778 0.000794551 0.000835626
0.000848806 0.000870648 0.000867244 0.000891472 0.00090545  0.00091422
0.000912231 0.000929564 0.00092733  0.000921762 0.000894926 0.000880795
0.000795283 0.000759451 0.000685956 0.000532047 0.000410114 0.000350316
0.000239536 0.000166662 0 ];

p15 = polyfit(P15, Eff15, 3);
y15 = polyval(p15,P15);

Cone_13000V = max(y15);

indexmax15 = find(max(y15) == y15);
xmax15 = P15(indexmax15);
ymax15 = y15(indexmax15);



% 15mm distance

% Conical / 15,000 V / 15mm

P13_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 ];
Eff13_1 = [ 0   7.8932E-05  0.000157233 0.000229079 0.000301476 0.000371972
0.000444312 0.000507286 0.00054996  0.000604383 0.000664206 0.000715912
0.000768694 0.000804193 0.000864145 0.000906378 0.000959169 0.000984484
0.001001631 0.001034561 0.001022601 0.001046887 0.001079207 0.001095448
0.001092824 0.001068371 0.001043042 0.000907219 0.000727739 0.000692223
0.000596823 0.000469757 0.000263723 0.000179275 0 ];

p13_1 = polyfit(P13_1, Eff13_1, 3);
y13_1 = polyval(p13_1,P13_1);

Cone_15000V_1 = max(y13_1);

indexmax13_1 = find(max(y13_1) == y13_1);
xmax13_1 = P13_1(indexmax13_1);
```

```
ymax13_1 = y13_1(indexmax13_1);


% Conical / 16,750 V / 15mm

P14_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 9.70476 9.9536  10.20244    10.45128    10.70012 ];
Eff14_1 = [ 0   5.82572E-05 0.000114395 0.000170629 0.000224196 0.000276109
0.000324734 0.000375649 0.000425627 0.000467284 0.000516622 0.000557009
0.000600614 0.000638028 0.000679557 0.000714653 0.000741312 0.000779468
0.000799777 0.000832592 0.000861679 0.000898104 0.000907345 0.00092689
0.000938623 0.000941892 0.000958345 0.000957343 0.000953213 0.000966251
0.000977892 0.000965291 0.00095403  0.000889382 0.000840151 0.000757221
0.00062923  0.000560107 0.000469279 0.00039394  0.000329022 0.00027301
0.000122358 0 ];

p14_1 = polyfit(P14_1, Eff14_1, 3);
y14_1 = polyval(p14_1,P14_1);

Cone_16750V_1 = max(y14_1);

indexmax14_1 = find(max(y14_1) == y14_1);
xmax14_1 = P14_1(indexmax14_1);
ymax14_1 = y14_1(indexmax14_1);


% Conical / 18,000 V / 15mm

P15_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 9.70476 9.9536  10.20244    10.45128    10.70012
10.94896    11.1978 11.44664    11.69548    11.94432    12.19316 ];
Eff15_1 = [ 0   4.94081E-05 9.88255E-05 0.00014692  0.000190615 0.00023587
0.00028251  0.000321924 0.000364478 0.000405751 0.000446573 0.000477303
0.000513797 0.000556549 0.000588943 0.000624728 0.000660797 0.000672455
0.000706916 0.000741972 0.000776563 0.000805956 0.000830263 0.000836108
0.000865241 0.000895507 0.0008913   0.000897572 0.000922285 0.000930081
0.000938571 0.000950654 0.000953999 0.000964983 0.000944634 0.000948718
0.000957757 0.000901626 0.000888009 0.000831743 0.000816747 0.000744856
0.000618552 0.000573386 0.00042711  0.000330914 0.000269614 0.000157991
9.51222E-05 0 ];

p15_1 = polyfit(P15_1, Eff15_1, 3);
y15_1 = polyval(p15_1,P15_1);

Cone_18000V_1 = max(y15_1);

indexmax15_1 = find(max(y15_1) == y15_1);
xmax15_1 = P15_1(indexmax15_1);
```

```
ymax15_1 = y15_1(indexmax15_1);



% 20mm distance

% Conical / 17,500 V / 20mm

P13_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 ];
Eff13_2 = [ 0   7.66524E-05 0.000148533 0.000220115 0.0002901   0.000354842
0.000418755 0.000476021 0.000532135 0.000588079 0.000647431 0.000705527
0.000755412 0.000806783 0.00084846  0.000869757 0.000917638 0.00096416
0.000979129 0.000996659 0.001022601 0.001029381 0.001066636 0.001060723
0.001040909 0.001073731 0.000979544 0.000921995 0.000815894 0.000798851
0.0007209   0.000647829 0.000616228 0.000448641 0.000320406 0.000237852
8.15492E-05 0 ];

p13_2 = polyfit(P13_2, Eff13_2, 3);
y13_2 = polyval(p13_2,P13_2);

Cone_17500V_2 = max(y13_2);

indexmax13_2 = find(max(y13_2) == y13_2);
xmax13_2 = P13_2(indexmax13_2);
ymax13_2 = y13_2(indexmax13_2);


% Conical / 19,500 V / 20mm

P14_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 9.70476 9.9536  10.20244    10.45128    10.70012
10.94896 ];
Eff14_2 = [ 0   5.625E-05   0.000109109 0.00016138  0.000212055 0.000260329
0.000311916 0.000356825 0.000398895 0.000444922 0.000490434 0.000537853
0.00057155  0.000615526 0.000655172 0.000681963 0.000722703 0.000756007
0.00078253  0.000813541 0.000843154 0.000872664 0.000901149 0.000915707
0.000931591 0.000958586 0.000984552 0.000951205 0.000921776 0.000915385
0.000903379 0.000858452 0.000873751 0.000861006 0.000773708 0.00070945
0.000639314 0.000558875 0.000507751 0.000436633 0.000383252 0.00030074
0.000224841 0.000115097 0 ];

p14_2 = polyfit(P14_2, Eff14_2, 3);
y14_2 = polyval(p14_2,P14_2);

Cone_19500V_2 = max(y14_2);

indexmax14_2 = find(max(y14_2) == y14_2);
```

```
xmax14_2 = P14_2(indexmax14_2);
ymax14_2 = y14_2(indexmax14_2);


% Conical / 20,750 V / 20mm

P15_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 9.70476 9.9536  10.20244    10.45128    10.70012
10.94896    11.1978 11.44664    11.69548    11.94432    12.19316    12.442 ];
Eff15_2 = [ 0   4.89875E-05 9.66605E-05 0.000142129 0.000188018 0.000231172
0.000270532 0.000311442 0.000355393 0.000396971 0.000429575 0.000470386
0.000507964 0.00054418  0.000574462 0.000606735 0.000637892 0.000667941
0.000702684 0.000730761 0.000758811 0.000780289 0.000811595 0.000832967
0.000851773 0.00086533  0.000885343 0.000894924 0.000910559 0.000917873
0.000923592 0.000940265 0.000915562 0.000923478 0.000916844 0.00088345
0.000866782 0.000844581 0.000782071 0.000713407 0.000667317 0.000599247
0.000559701 0.000523872 0.000480461 0.000446576 0.000371925 0.000309143
0.000234322 0.000142411 0 ];

p15_2 = polyfit(P15_2, Eff15_2, 3);
y15_2 = polyval(p15_2,P15_2);

Cone_20750V_2 = max(y15_2);

indexmax15_2 = find(max(y15_2) == y15_2);
xmax15_2 = P15_2(indexmax15_2);
ymax15_2 = y15_2(indexmax15_2);


% FIGURE OF CONICAL EFFICIENCY CURVES AT 10, 15, AND 20 MM.

figure(5);

% 10mm distance

subplot(3,3,1);
hold on
plot(P13, Eff13,'o')
plot(P13,y13)
grid on
strmax13 = ['Max Eff = ',num2str(ymax13)];
text(xmax13,ymax13,strmax13,'HorizontalAlignment','right');
title('Conical / 11,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,4);
hold on
plot(P14, Eff14,'o')
plot(P14,y14)
```

```
grid on
strmax14 = ['Max Eff = ',num2str(ymax14)];
text(xmax14,ymax14,strmax14,'HorizontalAlignment','right');
title('Conical / 12,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off

subplot(3,3,7);
hold on
plot(P15, Eff15,'o')
plot(P15,y15)
grid on
strmax15 = ['Max Eff = ',num2str(ymax15)];
text(xmax15,ymax15,strmax15,'HorizontalAlignment','right');
title('Conical / 13,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off

% 15mm distance

subplot(3,3,2);
hold on
plot(P13_1, Eff13_1,'o')
plot(P13_1,y13_1)
grid on
strmax13_1 = ['Max Eff = ',num2str(ymax13_1)];
text(xmax13_1,ymax13_1,strmax13_1,'HorizontalAlignment','right');
title('Conical / 15,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off

subplot(3,3,5);
hold on
plot(P14_1, Eff14_1,'o')
plot(P14_1,y14_1)
grid on
strmax14_1 = ['Max Eff = ',num2str(ymax14_1)];
text(xmax14_1,ymax14_1,strmax14_1,'HorizontalAlignment','right');
title('Conical / 16,750V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off

subplot(3,3,8);
hold on
plot(P15_1, Eff15_1,'o')
plot(P15_1,y15_1)
grid on
strmax15_1 = ['Max Eff = ',num2str(ymax15_1)];
```

```
text(xmax15_1,ymax15_1,strmax15_1,'HorizontalAlignment','right');
title('Conical / 18,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off


% 20mm distance

subplot(3,3,3);
hold on
plot(P13_2, Eff13_2,'o')
plot(P13_2,y13_2)
grid on
strmax13_2 = ['Max Eff = ',num2str(ymax13_2)];
text(xmax13_2,ymax13_2,strmax13_2,'HorizontalAlignment','right');
title('Conical / 17,500V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off

subplot(3,3,6);
hold on
plot(P14_2, Eff14_2,'o')
plot(P14_2,y14_2)
grid on
strmax14_2 = ['Max Eff = ',num2str(ymax14_2)];
text(xmax14_2,ymax14_2,strmax14_2,'HorizontalAlignment','right');
title('Conical / 19,500V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off

subplot(3,3,9);
hold on
plot(P15_2, Eff15_2,'o')
plot(P15_2,y15_2)
grid on
strmax15_2 = ['Max Eff = ',num2str(ymax15_2)];
text(xmax15_2,ymax15_2,strmax15_2,'HorizontalAlignment','right');
title('Conical / 20,750V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off



% BEGINNING OF PARABOLIC DATA FOR SHAPE ANALYSIS

% 10mm distance
```

```
% Parabolic / 11,000 V / 10mm

P16 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 ];
Eff16 = [ 0 0.000169258 0.000331573 0.000490935 0.000644078 0.000770094
0.000895768 0.001014682 0.001088294 0.00115459  0.001231218 0.001308064
0.001374899 0.001433424 0.001397467 0.001368977 0.001402675 0.001416563
0.001312404 0.001145119 0.000973678 0.000681575 0.000507338 0 ];

p16 = polyfit(P16, Eff16, 3);
y16 = polyval(p16,P16);

Parabolic_11000V = max(y16);

indexmax16 = find(max(y16) == y16);
xmax16 = P16(indexmax16);
ymax16 = y16(indexmax16);


% Parabolic / 12,000 V / 10mm

P17 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 ];
Eff17 = [ 0 0.00013269  0.000262184 0.000376966 0.000485128 0.000592029
0.000703906 0.000822937 0.000903751 0.000989535 0.001069277 0.001135967
0.001203212 0.001233233 0.001269257 0.001323004 0.001361615 0.001398344
0.001340105 0.001319984 0.001320892 0.001286068 0.001222722 0.00118036
0.000925279 0.000692727 0.000441862 0.000187625 0 ];

p17 = polyfit(P17, Eff17, 3);
y17 = polyval(p17,P17);

Parabolic_12000V = max(y17);

indexmax17 = find(max(y17) == y17);
xmax17 = P17(indexmax17);
ymax17 = y17(indexmax17);


% Parabolic / 13,000 V / 10mm

P18 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 ];
Eff18 = [ 0 0.000106179 0.000208339 0.000308799 0.000406739 0.000497075
0.000586116 0.000659085 0.000743352 0.000797701 0.000877691 0.00095568
0.000992445 0.001084055 0.001148644 0.0011922   0.001217185 0.001277326
0.001283749 0.001314006 0.00132901  0.001295133 0.001312277 0.001299838
0.001280217 0.001248661 0.001146297 0.001125749 0.001040831 0.000856712
0.00066163  0.000455891 0.000283678 0 ];
```

```
p18 = polyfit(P18, Eff18, 3);
y18 = polyval(p18,P18);

Parabolic_13000V = max(y18);

indexmax18 = find(max(y18) == y18);
xmax18 = P18(indexmax18);
ymax18 = y18(indexmax18);



% 15mm distance

% Parabolic / 15,000 V / 15mm

P16_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 ];
Eff16_1 = [ 0   0.000112373 0.000220141 0.000319159 0.000415731 0.000512795
0.000610684 0.00069957  0.000773718 0.000863075 0.000939514 0.001018268
0.00104876  0.001119588 0.001179429 0.001208532 0.001267423 0.001299845
0.001351582 0.001366484 0.001419344 0.00142039  0.00138196  0.00130111
0.001292511 0.001221912 0.001124322 0.001069244 0.000919716 0.000721833
0.000566948 0.000402202 0.000186113 0 ];

p16_1 = polyfit(P16_1, Eff16_1, 3);
y16_1 = polyval(p16_1,P16_1);

Parabolic_15000V_1 = max(y16_1);

indexmax16_1 = find(max(y16_1) == y16_1);
xmax16_1 = P16_1(indexmax16_1);
ymax16_1 = y16_1(indexmax16_1);


% Parabolic / 16,750 V / 15mm

P17_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 9.70476 ];
Eff17_1 = [ 0   8.28059E-05 0.000162079 0.000233611 0.000301752 0.000369876
0.000433156 0.00049495  0.000565698 0.000639248 0.00070113  0.000757888
0.000805246 0.000859951 0.000901539 0.000946981 0.000998803 0.001004257
0.001042782 0.001061202 0.001094591 0.001090419 0.001121219 0.001142258
0.001155082 0.001148911 0.001136476 0.001094295 0.001102714 0.001084984
0.001064896 0.000994654 0.000908807 0.000780765 0.000672619 0.000580396
0.000408459 0.000266891 0.000174708 0 ];

p17_1 = polyfit(P17_1, Eff17_1, 3);
y17_1 = polyval(p17_1,P17_1);
```

```
Parabolic_16750V_1 = max(y17_1);

indexmax17_1 = find(max(y17_1) == y17_1);
xmax17_1 = P17_1(indexmax17_1);
ymax17_1 = y17_1(indexmax17_1);


% Parabolic / 18,000 V / 15mm

P18_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 9.70476 9.9536  10.20244    10.45128    10.70012
10.94896 ];
Eff18_1 = [ 0   6.41153E-05 0.000127741 0.000188816 0.000247144 0.000304472
0.000358614 0.000415189 0.000470673 0.000522875 0.000574331 0.000621656
0.000669501 0.000708299 0.000750535 0.000781569 0.000811529 0.000862671
0.000898065 0.000920143 0.000950635 0.000984042 0.000998302 0.000988459
0.001004308 0.001014534 0.001020139 0.001023054 0.001023278 0.001020301
0.001011949 0.001007831 0.000973844 0.00093611  0.000897706 0.000832462
0.000764721 0.000647472 0.000609522 0.000483458 0.000375317 0.000322074
0.000226093 0.000148145 0 ];

p18_1 = polyfit(P18_1, Eff18_1, 3);
y18_1 = polyval(p18_1,P18_1);

Parabolic_18000V_1 = max(y18_1);

indexmax18_1 = find(max(y18_1) == y18_1);
xmax18_1 = P18_1(indexmax18_1);
ymax18_1 = y18_1(indexmax18_1);



% 20mm distance

% Parabolic / 17,500 V / 20mm

P16_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 ];
Eff16_2 = [ 0   9.34574E-05 0.00017841  0.000261112 0.00034748  0.000421472
0.000494612 0.000563125 0.000633568 0.000685995 0.000750278 0.000797064
0.000855008 0.000899167 0.00094535  0.00098192  0.001020707 0.001042853
0.001067143 0.001056027 0.001086905 0.001098021 0.001071275 0.001051087
0.00097225  0.000925279 0.000936241 0.00087817  0.000808552 0.000752188
0.000638346 0.000587094 0.000401032 0.000255011 0 ];

p16_2 = polyfit(P16_2, Eff16_2, 3);
y16_2 = polyval(p16_2,P16_2);
```

```
Parabolic_17500V_2 = max(y16_2);

indexmax16_2 = find(max(y16_2) == y16_2);
xmax16_2 = P16_2(indexmax16_2);
ymax16_2 = y16_2(indexmax16_2);


% Parabolic / 19,500 V / 20mm

P17_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 9.70476 9.9536  10.20244    10.45128    10.70012 ];
Eff17_2 = [ 0   7.23253E-05 0.000138355 0.000203464 0.000270466 0.000331377
0.000389148 0.000448405 0.000499243 0.000554346 0.00059954  0.000653485
0.000693405 0.000740417 0.000778001 0.000809786 0.000854599 0.000890086
0.000914671 0.000948412 0.000970145 0.001006036 0.001022455 0.001040453
0.001035224 0.00103813  0.001036851 0.001035443 0.001035983 0.00104792
0.001023005 0.00101448  0.000985605 0.000922098 0.00088671  0.000816568
0.000748983 0.000679492 0.000521056 0.000423205 0.00035649  0.000286608
0.000123115 0 ];

p17_2 = polyfit(P17_2, Eff17_2, 3);
y17_2 = polyval(p17_2,P17_2);

Parabolic_19500V_2 = max(y17_2);

indexmax17_2 = find(max(y17_2) == y17_2);
xmax17_2 = P17_2(indexmax17_2);
ymax17_2 = y17_2(indexmax17_2);


% Parabolic / 20,750 V / 20mm

P18_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 7.4652  7.71404 7.96288 8.21172 8.46056 8.7094
8.95824 9.20708 9.45592 9.70476 9.9536  10.20244    10.45128    10.70012
10.94896    11.1978 11.44664    11.69548    11.94432 ];
Eff18_2 = [ 0   5.95538E-05 0.000117418 0.000173579 0.000229806 0.000284054
0.000338297 0.000396181 0.000440773 0.000480759 0.000523736 0.000556193
0.000589933 0.00063693  0.000666636 0.000705876 0.000751782 0.000779057
0.000806669 0.000832399 0.000866843 0.00089693  0.000922326 0.000941477
0.000974567 0.000997843 0.000991919 0.001005495 0.001006835 0.000975102
0.000987308 0.000986915 0.000994069 0.000986714 0.000980307 0.000909146
0.000893774 0.000867332 0.000834598 0.000787733 0.000743367 0.000693577
0.000636246 0.000574744 0.000472135 0.000415046 0.000336242 0.00018719  0 ];

p18_2 = polyfit(P18_2, Eff18_2, 3);
y18_2 = polyval(p18_2,P18_2);

Parabolic_20750V_2 = max(y18_2);
```

```
indexmax18_2 = find(max(y18_2) == y18_2);
xmax18_2 = P18_2(indexmax18_2);
ymax18_2 = y18_2(indexmax18_2);


% FIGURE OF PARABOLIC EFFICIENCY CURVES AT 10, 15, AND 20 MM.

figure(6);

% 10mm distance

subplot(3,3,1);
hold on
plot(P16, Eff16,'o')
plot(P16,y16)
grid on
strmax16 = ['Max Eff = ',num2str(ymax16)];
text(xmax16,ymax16,strmax16,'HorizontalAlignment','right');
title('Parabolic / 11,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,4);
hold on
plot(P17, Eff17,'o')
plot(P17,y17)
grid on
strmax17 = ['Max Eff = ',num2str(ymax17)];
text(xmax17,ymax17,strmax17,'HorizontalAlignment','right');
title('Parabolic / 12,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.002]);
hold off

subplot(3,3,7);
hold on
plot(P18, Eff18,'o')
plot(P18,y18)
grid on
strmax18 = ['Max Eff = ',num2str(ymax18)];
text(xmax18,ymax18,strmax18,'HorizontalAlignment','right');
title('Parabolic / 13,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

% 15mm distance

subplot(3,3,2);
hold on
plot(P16_1, Eff16_1,'o')
plot(P16_1,y16_1)
```

```
grid on
strmax16_1 = ['Max Eff = ',num2str(ymax16_1)];
text(xmax16_1,ymax16_1,strmax16_1,'HorizontalAlignment','right');
title('Parabolic / 15,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off

subplot(3,3,5);
hold on
plot(P17_1, Eff17_1,'o')
plot(P17_1,y17_1)
grid on
strmax17_1 = ['Max Eff = ',num2str(ymax17_1)];
text(xmax17_1,ymax17_1,strmax17_1,'HorizontalAlignment','right');
title('Parabolic / 16,750V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off

subplot(3,3,8);
hold on
plot(P18_1, Eff18_1,'o')
plot(P18_1,y18_1)
grid on
strmax18_1 = ['Max Eff = ',num2str(ymax18_1)];
text(xmax18_1,ymax18_1,strmax18_1,'HorizontalAlignment','right');
title('Parabolic / 18,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0015]);
hold off


% 20mm distance

subplot(3,3,3);
hold on
plot(P16_2, Eff16_2,'o')
plot(P16_2,y16_2)
grid on
strmax16_2 = ['Max Eff = ',num2str(ymax16_2)];
text(xmax16_2,ymax16_2,strmax16_2,'HorizontalAlignment','right');
title('Parabolic / 17,500V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,6);
hold on
plot(P17_2, Eff17_2,'o')
plot(P17_2,y17_2)
grid on
strmax17_2 = ['Max Eff = ',num2str(ymax17_2)];
```

```
text(xmax17_2,ymax17_2,strmax17_2,'HorizontalAlignment','right');
title('Parabolic / 19,500V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,9);
hold on
plot(P18_2, Eff18_2,'o')
plot(P18_2,y18_2)
grid on
strmax18_2 = ['Max Eff = ',num2str(ymax18_2)];
text(xmax18_2,ymax18_2,strmax18_2,'HorizontalAlignment','right');
title('Parabolic / 20,750V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off



% BEGINNING OF 4-STAGE DATA FOR MULTI-STAGE ANALYSIS

% 10mm distance

% 4-Stage / 8,500 V / 10mm

P19 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 ];
Eff19 = [ 0 6.70501E-05 0.000128005 0.000172197 0.000219437 0.000255578
0.000291511 0.000330679 0.000356291 0.000373498 0.000369449 0.000360537
0.000332803 0.00030154  0.000225903 0.00020422  0.000113365 0 ];

p19 = polyfit(P19, Eff19, 3);
y19 = polyval(p19,P19);

FourStage_8500V = max(y19);

indexmax19 = find(max(y19) == y19);
xmax19 = P19(indexmax19);
ymax19 = y19(indexmax19);


% 4-Stage / 10,000 V / 10mm

P20 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 ];
Eff20 = [ 0 3.62521E-05 6.91587E-05 9.86231E-05 0.000126307 0.000143035
0.000165189 0.000183351 0.000196162 0.000206753 0.000217241 0.000221997
0.000228461 0.000224843 0.0002306   0.000231028 0.000229317 0.000214167
0.000196017 0.000187303 0.000161985 0.000143229 0.000117439 8.34887E-05 0 ];

p20 = polyfit(P20, Eff20, 3);
y20 = polyval(p20,P20);
```

```
FourStage_10000V = max(y20);

indexmax20 = find(max(y20) == y20);
xmax20 = P20(indexmax20);
ymax20 = y20(indexmax20);


% 4-Stage / 11,500 V / 10mm

P21 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 ];
Eff21 = [ 0 3.55519E-05 6.89272E-05 0.000101035 0.000132306 0.000161149
0.000187946 0.000211666 0.0002328   0.000252587 0.000267977 0.0002888
0.000302018 0.000313063 0.000321365 0.000330764 0.000341247 0.000344139
0.000344862 0.00034685  0.000339801 0.000311795 0.000294775 0.000262364
0.000243352 0.000208226 0.000155354 0.000136886 8.61873E-05 0 ];

p21 = polyfit(P21, Eff21, 3);
y21 = polyval(p21,P21);

FourStage_11500V = max(y21);

indexmax21 = find(max(y21) == y21);
xmax21 = P21(indexmax21);
ymax21 = y21(indexmax21);



% 15mm distance

% 4-Stage / 10,000 V / 15mm

P19_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 ];
Eff19_1 = [ 0   6.31172E-05 0.000122095 0.000176935 0.000225566 0.000241634
0.00026385  0.000275232 0.000277302 0.00025609  0.000217289 0.000170727
0.000130373 9.41584E-05 0 ];

p19_1 = polyfit(P19_1, Eff19_1, 3);
y19_1 = polyval(p19_1,P19_1);

FourStage_10000V_1 = max(y19_1);

indexmax19_1 = find(max(y19_1) == y19_1);
xmax19_1 = P19_1(indexmax19_1);
ymax19_1 = y19_1(indexmax19_1);


% 4-Stage / 11,500 V / 15mm
```

```
P20_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 ];
Eff20_1 = [ 0   4.54876E-05 8.70144E-05 0.000122907 0.000158318 0.000187323
0.000210285 0.000230528 0.000236873 0.000249429 0.000243289 0.000238584
0.000234969 0.000227137 0.000180284 0.000147807 0.000114662 8.09823E-05 0 ];

p20_1 = polyfit(P20_1, Eff20_1, 3);
y20_1 = polyval(p20_1,P20_1);

FourStage_11500V_1 = max(y20_1);

indexmax20_1 = find(max(y20_1) == y20_1);
xmax20_1 = P20_1(indexmax20_1);
ymax20_1 = y20_1(indexmax20_1);


% 4-Stage / 13,000 V / 15mm

P21_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 ];
Eff21_1 = [ 0   3.26794E-05 6.36129E-05 9.14671E-05 0.000118945 0.000143677
0.000164524 0.000184056 0.000200918 0.000212098 0.000226312 0.000236599
0.000244642 0.000240217 0.000240901 0.000237977 0.000226965 0.000222112
0.000211659 0.000191107 0.00017545  0.000137187 9.03379E-05 6.85451E-05 0 ];

p21_1 = polyfit(P21_1, Eff21_1, 3);
y21_1 = polyval(p21_1,P21_1);

FourStage_13000V_1 = max(y21_1);

indexmax21_1 = find(max(y21_1) == y21_1);
xmax21_1 = P21_1(indexmax21_1);
ymax21_1 = y21_1(indexmax21_1);



% 20mm distance

% 4-Stage / 10,000 V / 20mm

P19_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884 ];
Eff19_2 = [ 0   8.02643E-05 0.00015039  0.000195169 0.000246707 0.000261915
0.000256689 0.000258366 0.000208035 0.000143444 0 ];

p19_2 = polyfit(P19_2, Eff19_2, 3);
y19_2 = polyval(p19_2,P19_2);

FourStage_10000V_2 = max(y19_2);

indexmax19_2 = find(max(y19_2) == y19_2);
```

```
xmax19_2 = P19_2(indexmax19_2);
ymax19_2 = y19_2(indexmax19_2);


% 4-Stage / 13,000 V / 20mm

P20_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326 ];
Eff20_2 = [ 0   4.14817E-05 7.83949E-05 0.000112845 0.000142574 0.000167463
0.000186207 0.000197883 0.000205787 0.000207408 0.000192925 0.000171795
0.000165364 0.000131373 8.14572E-05 0 ];

p20_2 = polyfit(P20_2, Eff20_2, 3);
y20_2 = polyval(p20_2,P20_2);

FourStage_13000V_2 = max(y20_2);

indexmax20_2 = find(max(y20_2) == y20_2);
xmax20_2 = P20_2(indexmax20_2);
ymax20_2 = y20_2(indexmax20_2);


% 4-stage / 16,000 V / 20mm

P21_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 ];
Eff21_2 = [ 0   2.40542E-05 4.63721E-05 6.73403E-05 8.52205E-05 0.000101906
0.000117714 0.000131325 0.000143513 0.00015254  0.000158259 0.000160579
0.000160741 0.00015459  0.000139173 0.00012688  0.000110915 0.000104369
9.08626E-05 7.23122E-05 3.2622E-05  0 ];

p21_2 = polyfit(P21_2, Eff21_2, 3);
y21_2 = polyval(p21_2,P21_2);

FourStage_16000V_2 = max(y21_2);

indexmax21_2 = find(max(y21_2) == y21_2);
xmax21_2 = P21_2(indexmax21_2);
ymax21_2 = y21_2(indexmax21_2);


% FIGURE OF 4-STAGE EFFICIENCY CURVES AT 10, 15, AND 20 MM.

figure(7);

% 10mm distance

subplot(3,3,1);
hold on
plot(P19, Eff19,'o')
plot(P19,y19)
grid on
```

```
strmax19 = ['Max Eff = ',num2str(ymax19)];
text(xmax19,ymax19,strmax19,'HorizontalAlignment','right');
title('4-Stage / 8,500V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,4);
hold on
plot(P20, Eff20,'o')
plot(P20,y20)
grid on
strmax20 = ['Max Eff = ',num2str(ymax20)];
text(xmax20,ymax20,strmax20,'HorizontalAlignment','right');
title('4-Stage / 10,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0003]);
hold off

subplot(3,3,7);
hold on
plot(P21, Eff21,'o')
plot(P21,y21)
grid on
strmax21 = ['Max Eff = ',num2str(ymax21)];
text(xmax21,ymax21,strmax21,'HorizontalAlignment','right');
title('4-Stage / 11,500V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0004]);
hold off

% 15mm distance

subplot(3,3,2);
hold on
plot(P19_1, Eff19_1,'o')
plot(P19_1,y19_1)
grid on
strmax19_1 = ['Max Eff = ',num2str(ymax19_1)];
text(xmax19_1,ymax19_1,strmax19_1,'HorizontalAlignment','right');
title('4-Stage / 10,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.00035]);
hold off

subplot(3,3,5);
hold on
plot(P20_1, Eff20_1,'o')
plot(P20_1,y20_1)
grid on
strmax20_1 = ['Max Eff = ',num2str(ymax20_1)];
text(xmax20_1,ymax20_1,strmax20_1,'HorizontalAlignment','right');
title('4-Stage / 11,500V / 15mm');
```

```
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0003]);
hold off

subplot(3,3,8);
hold on
plot(P21_1, Eff21_1,'o')
plot(P21_1,y21_1)
grid on
strmax21_1 = ['Max Eff = ',num2str(ymax21_1)];
text(xmax21_1,ymax21_1,strmax21_1,'HorizontalAlignment','right');
title('4-Stage / 13,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0003]);
hold off


% 20mm distance

subplot(3,3,3);
hold on
plot(P19_2, Eff19_2,'o')
plot(P19_2,y19_2)
grid on
strmax19_2 = ['Max Eff = ',num2str(ymax19_2)];
text(xmax19_2,ymax19_2,strmax19_2,'HorizontalAlignment','right');
title('4-Stage / 10,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,6);
hold on
plot(P20_2, Eff20_2,'o')
plot(P20_2,y20_2)
grid on
strmax20_2 = ['Max Eff = ',num2str(ymax20_2)];
text(xmax20_2,ymax20_2,strmax20_2,'HorizontalAlignment','right');
title('4-Stage / 13,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,9);
hold on
plot(P21_2, Eff21_2,'o')
plot(P21_2,y21_2)
grid on
strmax21_2 = ['Max Eff = ',num2str(ymax21_2)];
text(xmax21_2,ymax21_2,strmax21_2,'HorizontalAlignment','right');
title('4-Stage / 16,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0002]);
```

```
hold off

% BEGINNING OF 6-STAGE DATA FOR MULTI-STAGE ANALYSIS

% 10mm distance

% 6-Stage / 8,500 V / 10mm

P22 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 ];
Eff22 = [ 0 3.84259E-05 7.28963E-05 9.98163E-05 0.000122938 0.000136754
0.000155646 0.000165797 0.000168836 0.000159875 0.000152574 0.000142675
0.000135344 0.000128034 0.00010615  8.0197E-05  3.59451E-05 0 ];

p22 = polyfit(P22, Eff22, 3);
y22 = polyval(p22,P22);

SixStage_8500V = max(y22);

indexmax22 = find(max(y22) == y22);
xmax22 = P22(indexmax22);
ymax22 = y22(indexmax22);


% 6-Stage / 10,000 V / 10mm

P23 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 ];
Eff23 = [ 0 2.55498E-05 4.93066E-05 7.08222E-05 9.08436E-05 0.000107578
0.000121025 0.000135265 0.000147023 0.000157333 0.000165849 0.000167856
0.000168325 0.000172872 0.000169651 0.000164026 0.000162977 0.000152596
0.00014523  0.000133597 0.000122519 0.000103676 7.8991E-05  6.19361E-05 0 ];

p23 = polyfit(P23, Eff23, 3);
y23 = polyval(p23,P23);

SixStage_10000V = max(y23);

indexmax23 = find(max(y23) == y23);
xmax23 = P23(indexmax23);
ymax23 = y23(indexmax23);


% 6-Stage / 11,500 V / 10mm

P24 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 ];
Eff24 = [ 0 1.89791E-05 3.69948E-05 5.38283E-05 6.88372E-05 8.52615E-05
9.94236E-05 0.000110234 0.000122545 0.000132661 0.000143548 0.000153277
0.000161485 0.000169078 0.00017534  0.000179194 0.000177267 0.000178519
```

```
0.000176881 0.000172471 0.000158855 0.000159829 0.000152604 0.000140488
0.000114528 0.000103566 7.76506E-05 4.68216E-05 0 ];

p24 = polyfit(P24, Eff24, 3);
y24 = polyval(p24,P24);

SixStage_11500V = max(y24);

indexmax24 = find(max(y24) == y24);
xmax24 = P24(indexmax24);
ymax24 = y24(indexmax24);



% 15mm distance

% 6-Stage / 10,000 V / 15mm

P22_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 ];
Eff22_1 = [ 0   3.66241E-05 7.14321E-05 0.000100792 0.000126798 0.000146422
0.000161215 0.000156384 0.000161819 0.000162608 0.000153574 0.000139478
0.000104792 7.04636E-05 0 ];

p22_1 = polyfit(P22_1, Eff22_1, 3);
y22_1 = polyval(p22_1,P22_1);

SixStage_10000V_1 = max(y22_1);

indexmax22_1 = find(max(y22_1) == y22_1);
xmax22_1 = P22_1(indexmax22_1);
ymax22_1 = y22_1(indexmax22_1);


% 6-Stage / 11,500 V / 15mm

P23_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 ];
Eff23_1 = [ 0   2.64106E-05 5.07084E-05 7.28934E-05 9.24205E-05 0.000110925
0.000128884 0.000141493 0.000145082 0.0001487   0.00015521  0.000156879
0.000143674 0.000134814 0.000122826 0.000102471 6.73789E-05 3.87114E-05 0 ];

p23_1 = polyfit(P23_1, Eff23_1, 3);
y23_1 = polyval(p23_1,P23_1);

SixStage_11500V_1 = max(y23_1);

indexmax23_1 = find(max(y23_1) == y23_1);
xmax23_1 = P23_1(indexmax23_1);
ymax23_1 = y23_1(indexmax23_1);
```

```
% 6-Stage / 13,000 V / 15mm

P24_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 ];
Eff24_1 = [ 0   1.88569E-05 3.66176E-05 5.30173E-05 6.85777E-05 8.35241E-05
9.705E-05   0.00010834  0.000117219 0.000124627 0.000130781 0.000135562
0.000141112 0.000144475 0.00014309  0.000146538 0.000143839 0.000141646
0.000126145 0.000114706 9.87899E-05 7.83734E-05 5.30626E-05 3.27804E-05 0 ];

p24_1 = polyfit(P24_1, Eff24_1, 3);
y24_1 = polyval(p24_1,P24_1);

SixStage_13000V_1 = max(y24_1);

indexmax24_1 = find(max(y24_1) == y24_1);
xmax24_1 = P24_1(indexmax24_1);
ymax24_1 = y24_1(indexmax24_1);


% 20mm distance

% 6-Stage / 10,000 V / 20mm

P22_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 ];
Eff22_2 = [ 0   5.18426E-05 9.73371E-05 0.000133309 0.000152354 0.000161347
0.000168224 0.000155528 0.000130605 0.000104273 6.84624E-05 0 ];

p22_2 = polyfit(P22_2, Eff22_2, 2);
y22_2 = polyval(p22_2,P22_2);

SixStage_10000V_2 = max(y22_2);

indexmax22_2 = find(max(y22_2) == y22_2);
xmax22_2 = P22_2(indexmax22_2);
ymax22_2 = y22_2(indexmax22_2);


% 6-Stage / 13,000 V / 20mm

P23_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 ];
Eff23_2 = [ 0   2.66381E-05 5.1732E-05  7.35443E-05 9.32272E-05 0.000108829
0.000125704 0.000125128 0.000133777 0.00014185  0.000144464 0.000150115
0.000136083 0.000109943 8.34184E-05 6.34287E-05 4.00646E-05 0 ];

p23_2 = polyfit(P23_2, Eff23_2, 3);
y23_2 = polyval(p23_2,P23_2);

SixStage_13000V_2 = max(y23_2);

indexmax23_2 = find(max(y23_2) == y23_2);
```

```
xmax23_2 = P23_2(indexmax23_2);
ymax23_2 = y23_2(indexmax23_2);


% 6-stage / 16,000 V / 20mm

P24_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 ];
Eff24_2 = [ 0   1.3284E-05  2.61176E-05 3.80507E-05 4.88831E-05 5.89148E-05
6.79959E-05 7.57285E-05 8.17387E-05 8.93429E-05 9.47576E-05 0.000100303
0.000105913 0.000106784 0.000102548 9.7413E-05  8.32817E-05 7.43039E-05
6.90377E-05 6.00132E-05 4.51227E-05 3.47445E-05 2.15085E-05 0 ];

p24_2 = polyfit(P24_2, Eff24_2, 3);
y24_2 = polyval(p24_2,P24_2);

SixStage_16000V_2 = max(y24_2);

indexmax24_2 = find(max(y24_2) == y24_2);
xmax24_2 = P24_2(indexmax24_2);
ymax24_2 = y24_2(indexmax24_2);


% FIGURE OF 6-STAGE EFFICIENCY CURVES AT 10, 15, AND 20 MM.

figure(8);

% 10mm distance

subplot(3,3,1);
hold on
plot(P22, Eff22,'o')
plot(P22,y22)
grid on
strmax22 = ['Max Eff = ',num2str(ymax22)];
text(xmax22,ymax22,strmax22,'HorizontalAlignment','right');
title('6-Stage / 8,500V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,4);
hold on
plot(P23, Eff23,'o')
plot(P23,y23)
grid on
strmax23 = ['Max Eff = ',num2str(ymax23)];
text(xmax23,ymax23,strmax23,'HorizontalAlignment','right');
title('6-Stage / 10,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off
```

```
subplot(3,3,7);
hold on
plot(P24, Eff24,'o')
plot(P24,y24)
grid on
strmax24 = ['Max Eff = ',num2str(ymax24)];
text(xmax24,ymax24,strmax24,'HorizontalAlignment','right');
title('6-Stage / 11,500V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

% 15mm distance

subplot(3,3,2);
hold on
plot(P22_1, Eff22_1,'o')
plot(P22_1,y22_1)
grid on
strmax22_1 = ['Max Eff = ',num2str(ymax22_1)];
text(xmax22_1,ymax22_1,strmax22_1,'HorizontalAlignment','right');
title('6-Stage / 10,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,5);
hold on
plot(P23_1, Eff23_1,'o')
plot(P23_1,y23_1)
grid on
strmax23_1 = ['Max Eff = ',num2str(ymax23_1)];
text(xmax23_1,ymax23_1,strmax23_1,'HorizontalAlignment','right');
title('6-Stage / 11,500V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
hold off

subplot(3,3,8);
hold on
plot(P24_1, Eff24_1,'o')
plot(P24_1,y24_1)
grid on
strmax24_1 = ['Max Eff = ',num2str(ymax24_1)];
text(xmax24_1,ymax24_1,strmax24_1,'HorizontalAlignment','right');
title('6-Stage / 13,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0002]);
hold off


% 20mm distance

subplot(3,3,3);
```

```
hold on
plot(P22_2, Eff22_2,'o')
plot(P22_2,y22_2)
grid on
strmax22_2 = ['Max Eff = ',num2str(ymax22_2)];
text(xmax22_2,ymax22_2,strmax22_2,'HorizontalAlignment','right');
title('6-Stage / 10,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0002]);
hold off

subplot(3,3,6);
hold on
plot(P23_2, Eff23_2,'o')
plot(P23_2,y23_2)
grid on
strmax23_2 = ['Max Eff = ',num2str(ymax23_2)];
text(xmax23_2,ymax23_2,strmax23_2,'HorizontalAlignment','right');
title('6-Stage / 13,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0002]);
hold off

subplot(3,3,9);
hold on
plot(P24_2, Eff24_2,'o')
plot(P24_2,y24_2)
grid on
strmax24_2 = ['Max Eff = ',num2str(ymax24_2)];
text(xmax24_2,ymax24_2,strmax24_2,'HorizontalAlignment','right');
title('6-Stage / 16,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.00015]);
hold off




% BEGINNING OF 8-STAGE DATA FOR MULTI-STAGE ANALYSIS

% 10mm distance

% 8-Stage / 8,500 V / 10mm

P25 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028 ];
Eff25 = [ 0 2.72744E-05 5.20848E-05 7.46563E-05 9.56979E-05 0.000113641
0.000125604 0.000138364 0.000145142 0.000150724 0.000143547 0.000144743
0.00013637  0.000111448 9.75509E-05 6.86838E-05 3.49883E-05 0 ];

p25 = polyfit(P25, Eff25, 2);
y25 = polyval(p25,P25);
```

```
EightStage_8500V = max(y25);

indexmax25 = find(max(y25) == y25);
xmax25 = P25(indexmax25);
ymax25 = y25(indexmax25);


% 8-Stage / 10,000 V / 10mm

P26 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 ];
Eff26 = [ 0 1.81978E-05 3.53376E-05 5.1102E-05  6.55967E-05 7.98799E-05
9.26818E-05 0.000102945 0.000110033 0.000119026 0.000128019 0.000136166
0.000142197 0.000144419 0.00014664  0.000146006 0.000147275 0.000131299
0.000118074 0.000102521 9.3105E-05  7.10984E-05 4.42249E-05 0 ];

p26 = polyfit(P26, Eff26, 3);
y26 = polyval(p26,P26);

EightStage_10000V = max(y26);

indexmax26 = find(max(y26) == y26);
xmax26 = P26(indexmax26);
ymax26 = y26(indexmax26);


% 8-Stage / 11,500 V / 10mm

P27 = [ 0   0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 6.221   6.46984
6.71868 6.96752 7.21636 ];
Eff27 = [ 0 1.22169E-05 2.40804E-05 3.56147E-05 4.64651E-05 5.7124E-05
6.62511E-05 7.5059E-05  8.32192E-05 9.13381E-05 9.89497E-05 0.000106717
0.000111889 0.000114503 0.000117056 0.000119881 0.000119754 0.000120024
0.000118007 0.000117376 0.000109013 0.000106569 0.000102121 9.11044E-05
7.87261E-05 6.34389E-05 5.47122E-05 3.63233E-05 1.71221E-05 0 ];

p27 = polyfit(P27, Eff27, 2);
y27 = polyval(p27,P27);

EightStage_11500V = max(y27);

indexmax27 = find(max(y27) == y27);
xmax27 = P27(indexmax27);
ymax27 = y27(indexmax27);



% 15mm distance
```

```
% 8-Stage / 10,000 V / 15mm

P25_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 ];
Eff25_1 = [ 0   2.74099E-05 5.30371E-05 7.42074E-05 9.35949E-05 0.00010808
0.000121673 0.000124557 0.000126576 0.000132119 0.00011566  9.54194E-05
5.59446E-05 2.59743E-05 0 ];

p25_1 = polyfit(P25_1, Eff25_1, 3);
y25_1 = polyval(p25_1,P25_1);

EightStage_10000V_1 = max(y25_1);

indexmax25_1 = find(max(y25_1) == y25_1);
xmax25_1 = P25_1(indexmax25_1);
ymax25_1 = y25_1(indexmax25_1);


% 8-Stage / 11,500 V / 15mm

P26_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 ];
Eff26_1 = [ 0   1.9719E-05  3.7871E-05  5.39951E-05 6.9385E-05  8.14103E-05
9.13236E-05 9.84739E-05 0.000105113 0.000110057 0.000108251 0.000108894
9.84739E-05 9.65201E-05 7.65908E-05 6.83847E-05 4.57919E-05 2.875E-05   0 ];

p26_1 = polyfit(P26_1, Eff26_1, 2);
y26_1 = polyval(p26_1,P26_1);

EightStage_11500V_1 = max(y26_1);

indexmax26_1 = find(max(y26_1) == y26_1);
xmax26_1 = P26_1(indexmax26_1);
ymax26_1 = y26_1(indexmax26_1);


% 8-Stage / 13,000 V / 15mm

P27_1 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 5.97216 ];
Eff27_1 = [ 0   1.37506E-05 2.67016E-05 3.94422E-05 5.0459E-05  5.98184E-05
6.93405E-05 7.81834E-05 8.54104E-05 9.31302E-05 9.93717E-05 0.000105695
0.000110377 0.000115304 0.000118425 0.000117029 0.000118261 0.000110294
0.000100521 8.27003E-05 7.22703E-05 6.38114E-05 3.97487E-05 1.7E-05 0 ];

p27_1 = polyfit(P27_1, Eff27_1, 3);
y27_1 = polyval(p27_1,P27_1);

EightStage_13000V_1 = max(y27_1);

indexmax27_1 = find(max(y27_1) == y27_1);
xmax27_1 = P27_1(indexmax27_1);
```

```
ymax27_1 = y27_1(indexmax27_1);


% 20mm distance

% 8-Stage / 10,000 V / 20mm

P25_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 ];
Eff25_2 = [ 0   3.39761E-05 6.35206E-05 8.97413E-05 0.000101928 9.75593E-05
8.61467E-05 6.7003E-05  5.30133E-05 0 ];

p25_2 = polyfit(P25_2, Eff25_2, 2);
y25_2 = polyval(p25_2,P25_2);

EightStage_10000V_2 = max(y25_2);

indexmax25_2 = find(max(y25_2) == y25_2);
xmax25_2 = P25_2(indexmax25_2);
ymax25_2 = y25_2(indexmax25_2);


% 8-Stage / 13,000 V / 20mm

P26_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326 ];
Eff26_2 = [ 0   1.77449E-05 3.40443E-05 4.91288E-05 6.1655E-05  7.0932E-05
7.70884E-05 8.63169E-05 8.68531E-05 8.92657E-05 8.69921E-05 7.64398E-05
7.06643E-05 5.39351E-05 2.98902E-05 0 ];

p26_2 = polyfit(P26_2, Eff26_2, 3);
y26_2 = polyval(p26_2,P26_2);

EightStage_13000V_2 = max(y26_2);

indexmax26_2 = find(max(y26_2) == y26_2);
xmax26_2 = P26_2(indexmax26_2);
ymax26_2 = y26_2(indexmax26_2);


% 8-stage / 16,000 V / 20mm

P27_2 = [ 0 0.24884 0.49768 0.74652 0.99536 1.2442  1.49304 1.74188 1.99072
2.23956 2.4884  2.73724 2.98608 3.23492 3.48376 3.7326  3.98144 4.23028
4.47912 4.72796 4.9768  5.22564 5.47448 5.72332 ];
Eff27_2 = [ 0   1.0649E-05  2.08673E-05 3.02091E-05 3.93082E-05 4.70121E-05
5.42307E-05 6.07215E-05 6.74548E-05 7.04272E-05 7.52194E-05 7.74032E-05
8.08002E-05 8.04362E-05 7.89803E-05 7.82524E-05 7.47341E-05 6.70302E-05
5.78704E-05 5.1865E-05  4.00361E-05 3.0573E-05  1.7349E-05  0 ];

p27_2 = polyfit(P27_2, Eff27_2, 2);
y27_2 = polyval(p27_2,P27_2);
```

```
EightStage_16000V_2 = max(y27_2);

indexmax27_2 = find(max(y27_2) == y27_2);
xmax27_2 = P27_2(indexmax27_2);
ymax27_2 = y27_2(indexmax27_2);


% FIGURE OF 8-STAGE EFFICIENCY CURVES AT 10, 15, AND 20 MM.

figure(9);

% 10mm distance

subplot(3,3,1);
hold on
plot(P25, Eff25,'o')
plot(P25,y25)
grid on
strmax25 = ['Max Eff = ',num2str(ymax25)];
text(xmax25,ymax25,strmax25,'HorizontalAlignment','right');
title('8-Stage / 8,500V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0002]);
hold off

subplot(3,3,4);
hold on
plot(P26, Eff26,'o')
plot(P26,y26)
grid on
strmax26 = ['Max Eff = ',num2str(ymax26)];
text(xmax26,ymax26,strmax26,'HorizontalAlignment','right');
title('8-Stage / 10,000V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0002]);
hold off

subplot(3,3,7);
hold on
plot(P27, Eff27,'o')
plot(P27,y27)
grid on
strmax27 = ['Max Eff = ',num2str(ymax27)];
text(xmax27,ymax27,strmax27,'HorizontalAlignment','right');
title('8-Stage / 11,500V / 10mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.00015]);
hold off

% 15mm distance

subplot(3,3,2);
```

```
hold on
plot(P25_1, Eff25_1,'o')
plot(P25_1,y25_1)
grid on
strmax25_1 = ['Max Eff = ',num2str(ymax25_1)];
text(xmax25_1,ymax25_1,strmax25_1,'HorizontalAlignment','right');
title('8-Stage / 10,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0002]);
hold off

subplot(3,3,5);
hold on
plot(P26_1, Eff26_1,'o')
plot(P26_1,y26_1)
grid on
strmax26_1 = ['Max Eff = ',num2str(ymax26_1)];
text(xmax26_1,ymax26_1,strmax26_1,'HorizontalAlignment','right');
title('8-Stage / 11,500V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.00015]);
hold off

subplot(3,3,8);
hold on
plot(P27_1, Eff27_1,'o')
plot(P27_1,y27_1)
grid on
strmax27_1 = ['Max Eff = ',num2str(ymax27_1)];
text(xmax27_1,ymax27_1,strmax27_1,'HorizontalAlignment','right');
title('8-Stage / 13,000V / 15mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.00015]);
hold off


% 20mm distance

subplot(3,3,3);
hold on
plot(P25_2, Eff25_2,'o')
plot(P25_2,y25_2)
grid on
strmax25_2 = ['Max Eff = ',num2str(ymax25_2)];
text(xmax25_2,ymax25_2,strmax25_2,'HorizontalAlignment','right');
title('8-Stage / 10,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.00015]);
hold off

subplot(3,3,6);
hold on
```

```
plot(P26_2, Eff26_2,'o')
plot(P26_2,y26_2)
grid on
strmax26_2 = ['Max Eff = ',num2str(ymax26_2)];
text(xmax26_2,ymax26_2,strmax26_2,'HorizontalAlignment','right');
title('8-Stage / 13,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0001]);
hold off

subplot(3,3,9);
hold on
plot(P27_2, Eff27_2,'o')
plot(P27_2,y27_2)
grid on
strmax27_2 = ['Max Eff = ',num2str(ymax27_2)];
text(xmax27_2,ymax27_2,strmax27_2,'HorizontalAlignment','right');
title('8-Stage / 16,000V / 20mm');
xlabel('Pressure');
ylabel('Efficiency');
ylim([0,0.0001]);
hold off


% Table of values for each factor and level

fprintf(' \n')
fprintf('Material Analysis \n')
fprintf('*****************************************************************************************************************************************************************************************
************************************************************************************************** \n')
fprintf('Aluminum / 7,500  V / 10mm : %.7f                  Aluminum / 10,000
V / 15mm : %.7f                    Aluminum / 10,000 V / 20mm : %.7f \n',
[Alum_Cylin_7500V*100, Alum_Cylin_1000V_1*100, Alum_Cylin_1000V_2*100])
fprintf('Aluminum / 8,750  V / 10mm : %.7f                  Aluminum / 12,500
V / 15mm : %.7f                    Aluminum / 15,000 V / 20mm : %.7f \n',
[Alum_Cylin_8750V*100, Alum_Cylin_12500V_1*100, Alum_Cylin_15000V_2*100])
fprintf('Aluminum / 10,000 V / 10mm : %.7f                  Aluminum / 15,000
V / 15mm : %.7f                    Aluminum / 17,500 V / 20mm : %.7f \n',
[Alum_Cylin_10000V*100, Alum_Cylin_15000V_1*100, Alum_Cylin_17500V_2*100])
fprintf('*****************************************************************************************************************************************************************************************
************************************************************************************************** \n')
fprintf('Conductive Graphite / 7,500  V / 10mm : %.7f       Conductive
Graphite / 10,000 V / 15mm : %.7f       Conductive Graphite / 10,000 V / 20mm
: %.7f \n', [CondGrap_Cylin_7500V*100, CondGrap_Cylin_10000V_1*100,
CondGrap_Cylin_10000V_2*100])
fprintf('Conductive Graphite / 8,750  V / 10mm : %.7f       Conductive
Graphite / 12,500 V / 15mm : %.7f       Conductive Graphite / 15,000 V / 20mm
: %.7f \n', [CondGrap_Cylin_8750V*100, CondGrap_Cylin_12500V_1*100,
CondGrap_Cylin_15000V_2*100])
fprintf('Conductive Graphite / 10,000 V / 10mm : %.7f       Conductive
Graphite / 15,000 V / 15mm : %.7f       Conductive Graphite / 17,500 V / 20mm
: %.7f \n', [CondGrap_Cylin_10000V*100, CondGrap_Cylin_15000V_1*100,
CondGrap_Cylin_17500V_2*100])
```

```
fprintf('*********************************************************************
*****************************************************************************
**************** \n')
fprintf('Copper / 7,500  V / 10mm : %.7f                    Copper / 10,000 V
/ 15mm : %.7f                    Copper / 10,000 V / 20mm : %.7f \n',
[Copper_Cylin_7500V*100, Copper_Cylin_10000V_1*100,
Copper_Cylin_10000V_2*100])
fprintf('Copper / 8,750  V / 10mm : %.7f                    Copper / 12,500 V
/ 15mm : %.7f                    Copper / 15,000 V / 20mm : %.7f \n',
[Copper_Cylin_8750V*100, Copper_Cylin_12500V_1*100,
Copper_Cylin_15000V_2*100])
fprintf('Copper / 10,000 V / 10mm : %.7f                    Copper / 15,000 V
/ 15mm : %.7f                    Copper / 17,500 V / 20mm : %.7f \n',
[Copper_Cylin_10000V*100, Copper_Cylin_15000V_1*100,
Copper_Cylin_17500V_2*100])
fprintf('*********************************************************************
*****************************************************************************
**************** \n')
fprintf(' \n')
fprintf(' \n')
fprintf('Shape Analysis \n')
fprintf('*********************************************************************
*****************************************************************************
**************** \n')
fprintf('Cylindrical / 11,000  V / 10mm : %.7f              Cylindrical /
15,000 V / 15mm : %.7f                 Cylindrical / 17,500 V / 20mm : %.7f
\n', [Cylin_11000V*100, Cylin_15000V_1*100, Cylin_17500V_2*100])
fprintf('Cylindrical / 12,000  V / 10mm : %.7f              Cylindrical /
16,750 V / 15mm : %.7f                 Cylindrical / 19,500 V / 20mm : %.7f
\n', [Cylin_12000V*100, Cylin_16750V_1*100, Cylin_19500V_2*100])
fprintf('Cylindrical / 13,000  V / 10mm : %.7f              Cylindrical /
18,000 V / 15mm : %.7f                 Cylindrical / 20,750 V / 20mm : %.7f
\n', [Cylin_13000V*100, Cylin_18000V_1*100, Cylin_20750V_2*100])
fprintf('*********************************************************************
*****************************************************************************
**************** \n')
fprintf('Conical / 11,000  V / 10mm : %.7f                  Conical / 15,000
V / 15mm : %.7f                  Conical / 17,500 V / 20mm : %.7f \n',
[Cone_11000V*100, Cone_15000V_1*100, Cone_17500V_2*100])
fprintf('Conical / 12,000  V / 10mm : %.7f                  Conical / 16,750
V / 15mm : %.7f                  Conical / 19,500 V / 20mm : %.7f \n',
[Cone_12000V*100, Cone_16750V_1*100, Cone_19500V_2*100])
fprintf('Conical / 13,000  V / 10mm : %.7f                  Conical / 18,000
V / 15mm : %.7f                  Conical / 20,750 V / 20mm : %.7f \n',
[Cone_13000V*100, Cone_18000V_1*100, Cone_20750V_2*100])
fprintf('*********************************************************************
*****************************************************************************
**************** \n')
fprintf('Parabolic / 11,000  V / 10mm : %.7f                Parabolic /
15,000 V / 15mm : %.7f                   Parabolic / 17,500 V / 20mm : %.7f
\n', [Parabolic_11000V*100, Parabolic_15000V_1*100, Parabolic_17500V_2*100])
fprintf('Parabolic / 12,000  V / 10mm : %.7f                Parabolic /
16,750 V / 15mm : %.7f                   Parabolic / 19,500 V / 20mm : %.7f
\n', [Parabolic_12000V*100, Parabolic_16750V_1*100, Parabolic_19500V_2*100])
fprintf('Parabolic / 13,000  V / 10mm : %.7f                Parabolic /
18,000 V / 15mm : %.7f                   Parabolic / 20,750 V / 20mm : %.7f
\n', [Parabolic_13000V*100, Parabolic_18000V_1*100, Parabolic_20750V_2*100])
```

```
fprintf('********************************************************************
*****************************************************************************
**************** \n')
fprintf(' \n')
fprintf(' \n')
fprintf('Multi-Stage Analysis \n')
fprintf('********************************************************************
*****************************************************************************
**************** \n')
fprintf('4-Stage / 8,500   V / 10mm : %.7f                  4-Stage / 10,000
V / 15mm : %.7f                   4-Stage / 10,000 V / 20mm : %.7f \n',
[FourStage_8500V*100, FourStage_10000V_1*100, FourStage_10000V_2*100])
fprintf('4-Stage / 10,000  V / 10mm : %.7f                  4-Stage / 11,500
V / 15mm : %.7f                   4-Stage / 13,000 V / 20mm : %.7f \n',
[FourStage_10000V*100, FourStage_11500V_1*100, FourStage_13000V_2*100])
fprintf('4-Stage / 11,500  V / 10mm : %.7f                  4-Stage / 13,000
V / 15mm : %.7f                   4-Stage / 16,000 V / 20mm : %.7f \n',
[FourStage_11500V*100, FourStage_13000V_1*100, FourStage_16000V_2*100])
fprintf('********************************************************************
*****************************************************************************
**************** \n')
fprintf('6-Stage / 8,500   V / 10mm : %.7f                  6-Stage / 10,000
V / 15mm : %.7f                   6-Stage / 10,000 V / 20mm : %.7f \n',
[SixStage_8500V*100, SixStage_10000V_1*100, SixStage_10000V_2*100])
fprintf('6-Stage / 10,000  V / 10mm : %.7f                  6-Stage / 11,500
V / 15mm : %.7f                   6-Stage / 13,000 V / 20mm : %.7f \n',
[SixStage_10000V*100, SixStage_11500V_1*100, SixStage_13000V_2*100])
fprintf('6-Stage / 11,500  V / 10mm : %.7f                  6-Stage / 13,000
V / 15mm : %.7f                   6-Stage / 16,000 V / 20mm : %.7f \n',
[SixStage_11500V*100, SixStage_13000V_1*100, SixStage_16000V_2*100])
fprintf('********************************************************************
*****************************************************************************
**************** \n')
fprintf('8-Stage / 8,500   V / 10mm : %.7f                  8-Stage / 10,000
V / 15mm : %.7f                   8-Stage / 10,000 V / 20mm : %.7f \n',
[EightStage_8500V*100, EightStage_10000V_1*100, EightStage_10000V_2*100])
fprintf('8-Stage / 10,000  V / 10mm : %.7f                  8-Stage / 11,500
V / 15mm : %.7f                   8-Stage / 13,000 V / 20mm : %.7f \n',
[EightStage_10000V*100, EightStage_11500V_1*100, EightStage_13000V_2*100])
fprintf('8-Stage / 11,500  V / 10mm : %.7f                  8-Stage / 13,000
V / 15mm : %.7f                   8-Stage / 16,000 V / 20mm : %.7f \n',
[EightStage_11500V*100, EightStage_13000V_1*100, EightStage_16000V_2*100])
fprintf('********************************************************************
*****************************************************************************
**************** \n')
```

APPENDIX I

The following Matlab® code was used for generating 3D plots of the maximum efficiency data results.

```
% Aaron Griffin
% Thesis Data Analysis
% Efficiency Data 3D Plots

close all
clear all

% Material Plot
electrode_gap1 = [ 10 10 10 15 15 15 20 20 20 ];
voltage1 = [ 7500 8750 10000 10000 12500 15000 10000 15000 17500 ];
aluminum_eff = [ 0.28498 0.25967 0.20816 0.34376 0.26367 0.11187 6.7964
0.26737 0.11109 ];
conductivegraphite_eff = [ 0.28505 0.27084 0.24065 0.39275 0.31566 0.24934
1.4155 0.338 0.23116 ];
copper_eff = [ 0.38366 0.34055 0.27872 0.7834 0.25437 0.084479 3.6213 0.2156
0.090846 ];

figure(1);
scatter3(electrode_gap1, voltage1,aluminum_eff, '*')
hold on
scatter3(electrode_gap1, voltage1,conductivegraphite_eff, '*')
hold on
scatter3(electrode_gap1, voltage1,copper_eff, 'g', '*')

title('Efficiency Analysis (Material)')
xlabel('Electrode Gap (mm)'), ylabel('Voltage (V)'), zlabel('Efficiency (%)')
legend('Aluminum','Graphite','Copper')

% Shape Plot
electrode_gap2 = [ 10 10 10 15 15 15 20 20 20 ];
voltage2 = [ 11000 12000 13000 15000 16750 18000 17500 19500 20750 ];
cylindrical_eff = [ 0.23173 0.2298 0.2161 0.24934 0.21775 0.11825 0.23116
0.17548 0.11687 ];
conical_eff = [ 0.10291 0.095345 0.094189 0.10799 0.097472 0.097054 0.10357
0.093318 0.091014 ];
parabolic_eff = [ 0.14622 0.14029 0.13564 0.13876 0.1167 0.10397 0.10866
0.10666 0.10127 ];

figure(2);
scatter3(electrode_gap2, voltage2,cylindrical_eff, '*')
hold on
scatter3(electrode_gap2, voltage2,conical_eff, '*')
hold on
scatter3(electrode_gap2, voltage2,parabolic_eff, 'g', '*')

title('Efficiency Analysis (Shape)')
xlabel('Electrode Gap (mm)'), ylabel('Voltage (V)'), zlabel('Efficiency (%)')
legend('Cylindrical','Conical','Parabolic')
```

```
% Multi-Stage Plot
electrode_gap3 = [ 10 10 10 15 15 15 20 20 20 ];
voltage3 = [ 8500 10000 11500 10000 11500 13000 10000 13000 16000 ];
FourStage_eff = [ 0.036673 0.023654 0.034512 0.027116 0.024888 0.024643
0.027263 0.020779 0.01564 ];
SixStage_eff = [ 0.016569 0.017457 0.018106 0.017009 0.015547 0.014766
0.016564 0.014365 0.009929 ];
EightStage_eff = [ 0.014753 0.014701 0.011924 0.012793 0.010843 0.011587
0.009855 0.008976 0.007918 ];

figure(3);
scatter3(electrode_gap3, voltage3,FourStage_eff, '*')
hold on
scatter3(electrode_gap3, voltage3,SixStage_eff, '*')
hold on
scatter3(electrode_gap3, voltage3,EightStage_eff, 'g', '*')

title('Efficiency Analysis (Multi-Stage)')
xlabel('Electrode Gap (mm)'), ylabel('Voltage (V)'), zlabel('Efficiency (%)')
legend('4-Stage','6-Stage','8-Stage')
```